AERIS TRANSFORMATIVE CONCEPTS

"Cleaner Air Through Smarter Transportation"

The purpose of this document is to share with stakeholders the set of Transformative Concepts developed by the Applications for the Environment: Real-time Information Synthesis (AERIS) Program.

TRANSFORMATIVE CONCEPTS are integrated operational concepts that use vehicle-to-vehicle (V2V) and/or vehicle-to-infrastructure (V2I) data and communications in innovative ways to operate surface transportation networks to reduce environmental impacts resulting from transportation-related emissions and fuel consumption. Transformative Concepts are intended to change the way transportation systems operate, with an emphasis on combining applications to provide significant environmental benefits to surface transportation networks. Transformative Concepts also consider regulatory/policy and educational tools.

TRANSFORMATIVE CONCEPT | Eco-Signal Operations

This Transformative Concept includes the use of Connected Vehicle technologies to decrease greenhouse gases (GHGs) and criteria air pollutant emissions on arterials by reducing idling, reducing the number of stops, reducing unnecessary accelerations and decelerations, and improving traffic flow at signalized intersections.

A foundational component of this concept utilizes Dedicated Short Range Communication (DSRC) wireless data communications among enabled vehicles and roadside infrastructure. This includes broadcasting signal phase and timing (SPaT) data to vehicles. Upon receiving this information, in-vehicle systems calculate and 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 is referred to as an eco-driving information application. Eco-driving assistance applications can also be more active, connected with vehicle systems to implement eco-driving tactics without distracting the driver. This Transformative Concept also considers eco traffic signal system applications. These applications would use real-time data collected from vehicles to optimize traffic signals for the environment. Transit Signal Priority (TSP) is also considered as part of this Transformative Concept.

TRANSFORMATIVE CONCEPT | Low-Emissions Zone

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

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 would be given an economic reward. Connected eco-driving—from the previous Transformative Concept—may also be implemented within the low-emissions zone to encourage eco-friendly driving.

Transit vehicles would be able to enter the low-emissions zone without paying a fee, encouraging commuters to use public transportation

TRANSFORMATIVE CONCEPT | Eco-Lanes

This Transformative Concept includes dedicated eco-lanes on freeways that are optimized for the environment. Drivers would be able to opt-in to these dedicated lanes to take advantage of eco-friendly applications. Low emission, high occupancy, freight, transit, and alternative fuel vehicles would be encouraged to use these lanes. Once in the eco-lanes, drivers would be provided with recommended or variable speeds optimized for the environment. Vehicles would be encouraged to drive at these speeds to improve throughput and reduce transportation-related emissions.

This Transformative Concept also considers eco-adaptive cruise control applications for the eco-lanes. These systems would automatically adjust a vehicle's speed targeted at fuel-consumption reduction. Eco-adaptive cruise control applications consider topography, 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.

TRANSFORMATIVE CONCEPT | Eco-Integrated Corridor Management (E-ICM)

This Transformative Concept includes the integrated operation of a major travel corridor to reduce transportation-related emissions on arterials and freeways. It includes the partnering of various surface transportation modes—such as highway agencies, transit agencies, commuter rail agencies—to treat a major travel corridor as an integrated asset coordinating their operations simultaneously, with a focus on reducing transportation related emissions. At the heart of this Transformative Concept is a real-time data fusion and decision support system. It involves using multi-source, real-time V2I data on arterials, freeways, and transit systems to determine the best operational decisions that that are environmentally beneficial to the corridor.

This Transformative Concept includes a combination of multi-modal applications defined in the other Transformative Concepts that together provide an overall environmental benefit to the corridor. It is expected that this Transformative Concept will be further defined after analysis of the other Transformative Concepts is completed.

TRANSFORMATIVE CONCEPT | Eco-Traveler Information

The AERIS Program seeks to enable the development of new, advanced traveler information applications through the provision of integrated, multi-source, multi-modal data. Although specific traveler information applications may not be directly developed by the AERIS Program, an open data / open source approach is intended to engage researchers and the private sector to spur innovation. Applications considered under this Transformative Concept include:

- Dynamic Eco-Routing – applications targeted at providing drivers with a recommended travel route that would be determined based on reducing emissions instead of reducing travel time.
- Multimodal Real-Time Traveler Information – applications that convey real-time pre-trip and en-route information to encourage greener transportation choices.
- Smart Parking – applications targeted at providing real-time parking information to reduce time searching for a parking space.

TRANSFORMATIVE CONCEPT | Support Alternative Fuel Vehicle Operations

This Transformative Concept supports operations of alternative fuel vehicles (AFV) — vehicles that run on a fuel other than "traditional" petroleum fuels, including vehicles whose engines do not solely use petroleum (e.g. electric cars and hybrid electric vehicles). Potential strategies include: (1) disseminating information on the locations and availability of charging/refueling stations, (2) applications targeted at engine performance optimization, and (3) smart parking systems whereby AFVs would have prioritized parking.

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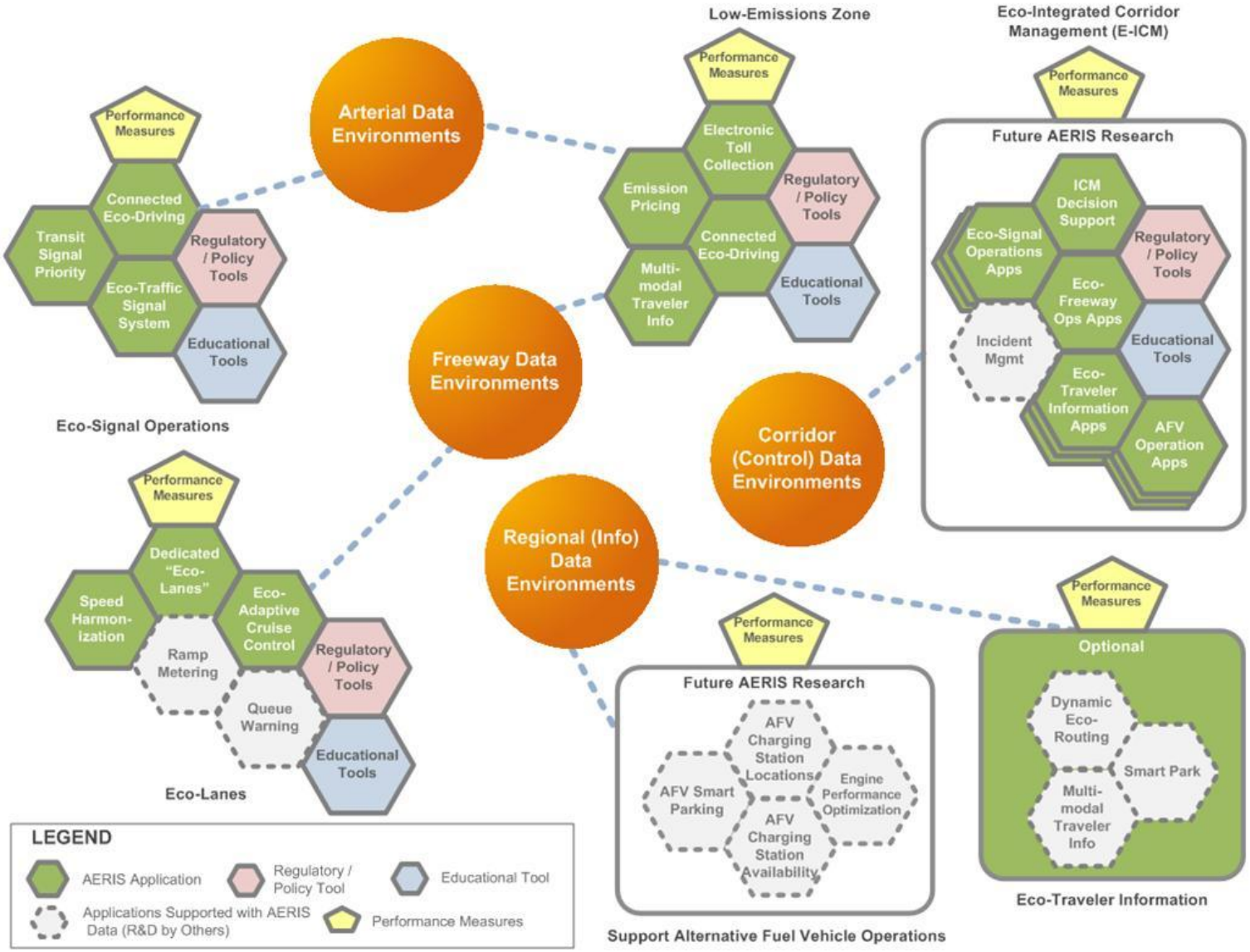
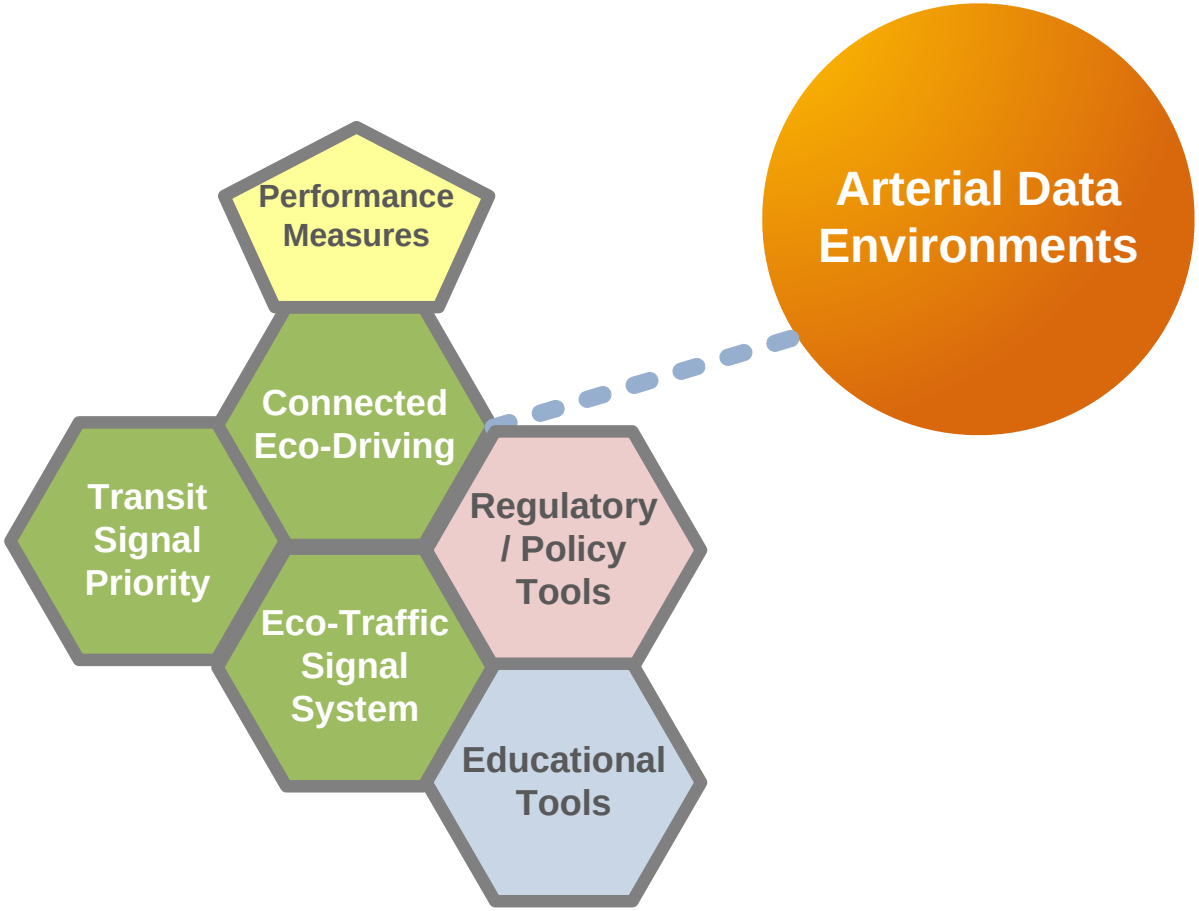
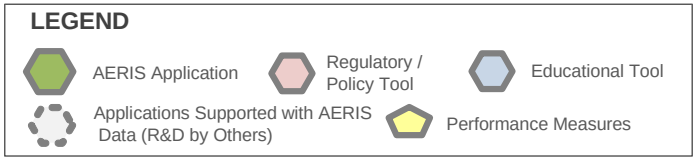


TRANSFORMATIVE CONCEPT | Eco-Signal Operations





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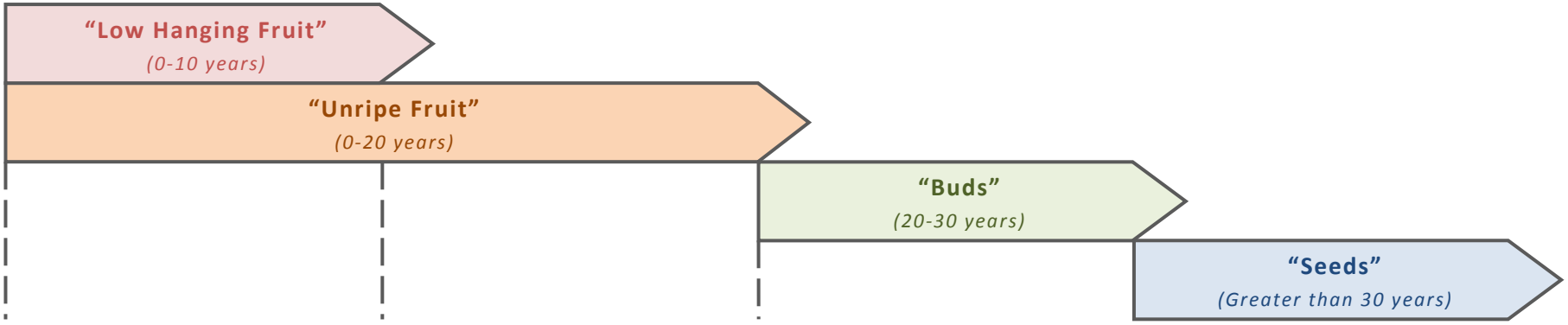

CONCEPT LEVEL 1	CONCEPT LEVEL 2	CONCEPT LEVEL 3	CONCEPT LEVEL 4
Application 1: Connected Eco-Driving • Connected Eco-Driving Information applications receive SPaT messages from RSE units connected to traffic signal controllers. • Applications provide drivers with information (i.e., recommended speed to pass the next signalized intersection when the light is green) so they can make decisions about their driving behavior. • Drivers must actively engage and follow recommendations in order to reduce emissions.	**Application 1: Connected Eco-Driving** • Connected Eco-Driving Information applications receive SPaT messages from RSE units connected to traffic signal controllers. • Applications and in-vehicle systems monitor current vehicle operation versus ideal operation for road-grade, predicted speed changes or braking, and real-time traffic changes. • Applications consider internal characteristics such as driver aggressiveness, energy/fuel consumption, brake regeneration, and engine/drive torque-speed	**Application 2: Eco-Traffic Signal System** • The Eco-Traffic Signal System would be similar to adaptive signal control systems; however the system would optimize the traffic signal(s) based on environmental measures of effectiveness. • The system utilizes Connected Vehicle data, including "here I am" (HIA) messages and emissions data collected from the vehicle, to accurately predict lane-specific platoon flow, platoon size, and other driving characteristics as vehicles approach traffic signals.	**Application 1: Connected Eco-Driving** • Connected Eco-Driving Information applications receive SPaT messages from RSE units connected to traffic signal controllers. • Applications and in-vehicle systems monitor current vehicle operation versus ideal operation for road-grade, predicted speed changes or braking, and real-time traffic changes. • Applications consider internal characteristics such as driver aggressiveness, energy/fuel consumption, brake regeneration, and engine/drive torque-speed

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	characteristics to optimize engine performance. • Applications and in-vehicle systems implement the eco-driving tactics (i.e., change gears, idle, or slow down in an eco-friendly manner as the vehicle approaches a traffic signal).	• The system coordinates control of traffic signals across a signal network, adjusting the lengths of signal phases based on prevailing traffic and environmental conditions collected from vehicles using vehicle-to-infrastructure (V2I) communications.	characteristics. • Applications receive information (i.e., location, speed, acceleration) from other vehicles and take into account vehicle interactions when implementing eco-driving tactics. • Applications and in-vehicle systems implement the eco-driving tactics (i.e., change gears, idle, or slow down in an eco-friendly manner as the vehicle approaches a traffic signal).

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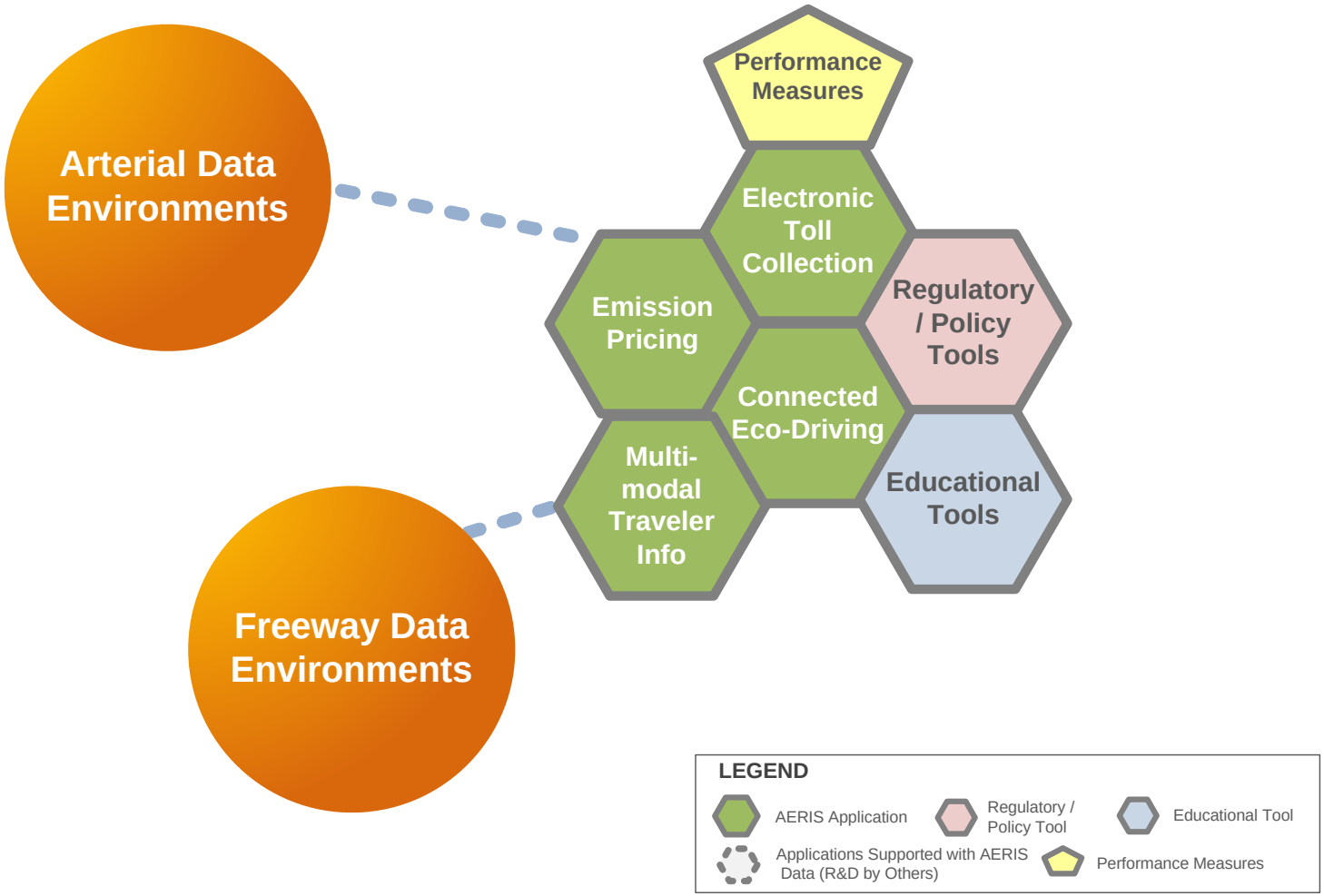

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CONCEPT LEVEL 1	CONCEPT LEVEL 2	CONCEPT LEVEL 3
Application 1: Electronic Toll Collection • ETC systems utilize DSRC technology to determine whether the vehicles passing are enrolled are registered in the low-emissions zone program. • ETC systems electronically debit the accounts of registered car owners without requiring them to stop. Note: Processing / electronic payment may be conducted at the back-office with vehicles being charged at a later time. • Automated enforcement technologies alert enforcers of violators.	**Application 1: Electronic Toll Collection** • ETC systems utilize DSRC technology to determine whether the vehicles passing are enrolled are registered in the low-emissions zone program. • ETC systems electronically debit the accounts of registered car owners without requiring them to stop. Note: Processing / electronic payment may be conducted at the back-office with vehicles being charged at a later time. • Automated enforcement technologies alert enforcers of violators.	**Application 1: Electronic Toll Collection** • ETC systems utilize DSRC technology to determine whether the vehicles passing are enrolled are registered in the low-emissions zone program. • ETC systems electronically debit the accounts of registered car owners without requiring them to stop. Note: Processing / electronic payment may be conducted at the back-office with vehicles being charged at a later time. • Automated enforcement technologies alert enforcers of violators.
Application 2: Emission Pricing • Low-emission zone fees are based on predetermined emission levels based on vehicle type. • Low emission vehicles would be charged a lower fee than higher	**Application 2: Emission Pricing** • Low-emission zone fees are based on emission data collected directly from a vehicle. • Vehicles would collect emissions data and disseminate this information to an	**Application 2: Emission Pricing** • Low-emission zone fees are based on emission data collected directly from a vehicle. • Vehicles would collect emissions data and disseminate this information to an

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emission vehicles to enter the low-emissions zone. • Drivers would be required to register their vehicle type prior to obtaining a toll tag. • In-vehicle units would communicate with RSE units to determine the vehicle fee.	RSE located prior to the entrance of the low-emissions zone. • Low emission vehicles would be charged a lower fee than higher emission vehicles to enter the low-emissions zone. • Drivers that do not elect to share their emissions data would be charged a flat fee. **Application 3: Multi-modal Traveler Information** • Utilize real-time data to communicate to travelers the current pricing scheme based on prevailing conditions prior to entering the low-emissions zone. • Travelers are provided with information about transit options for entering the low-emissions zone. • Information is conveyed to travelers via websites, personal mobile devices, and in-vehicle devices.	RSE located prior to the entrance of the low-emissions zone. • Low emission vehicles would be charged a lower fee than higher emission vehicles to enter the low-emissions zone. • Drivers that do not elect to share their emissions data would be charged a flat fee. • Includes refunds (or incentives) based on a vehicle's driving style within the low-emissions zone. Emissions data is collected from the vehicle while it is inside the low-emissions zone and sent to an RSE upon leaving the zone for a potential incentive. **Application 3: Multi-modal Traveler Information** • Utilize real-time data to communicate to travelers the current pricing scheme based on prevailing conditions prior to entering the low-emissions zone. • Travelers are provided with information about transit options for entering the low-emissions zone. • Information is conveyed to travelers via websites, personal mobile devices, and in-vehicle devices.

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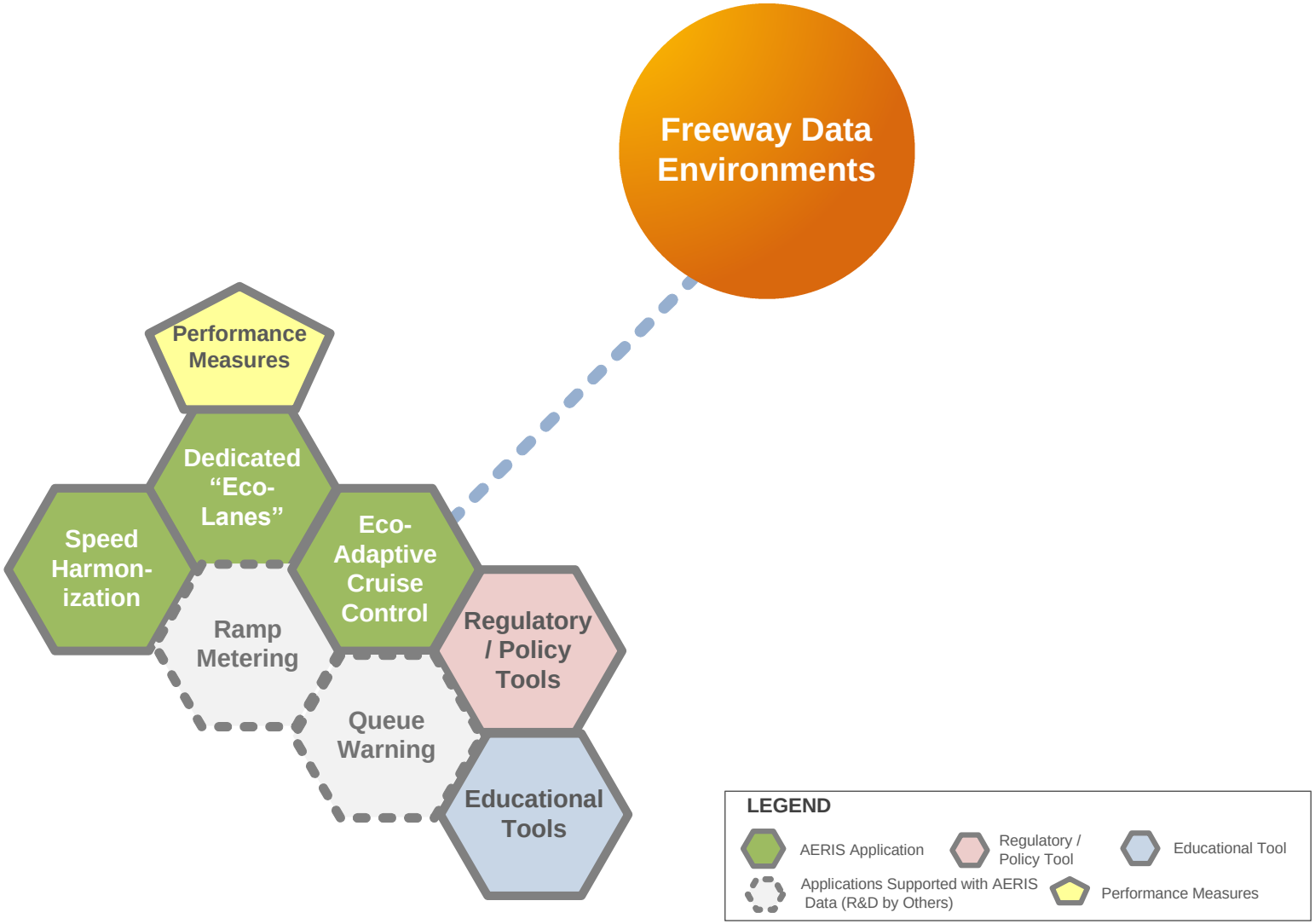
		Application 4: Eco-Driving Information and Assistance • Connected Eco-Driving Information applications receive SPaT messages and provide drivers with information (i.e., recommended speed to pass the next signalized intersection when the light is green). • Includes refunds (or incentives) based on a vehicle's driving style within the low-emissions zone.

TRANSFORMATIVE CONCEPT | Eco-Lanes



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Application 1: Dedicated Eco-Lanes • Lane use control signs, static signs, and/or pavement markings indicate that *one lane is dedicated* for use by eco-friendly vehicles (e.g., low emission vehicles, high occupancy vehicles, transit vehicles, and designated freight vehicles). • Eco-lane systems utilize DSRC technology to determine whether the vehicles passing are eco-friendly vehicles. • Access to the eco-lanes would be based on predetermined emission levels based on vehicle type. • Drivers would be required to register their vehicle type prior to obtaining a DSRC tag. • Automated enforcement technologies identify vehicle type and mail citations to violators.	**Application 1: Dedicated Eco-Lanes** • Lane use control signs, static signs, and/or pavement markings indicate that *one lane is dedicated* for use by eco-friendly vehicles (e.g., low emission vehicles, high occupancy vehicles, transit vehicles, and designated freight vehicles). • Eco-lane systems utilize DSRC technology to determine whether the vehicles passing are eco-friendly vehicles. • Access to the eco-lanes would be based on real-time emission data collected directly from the vehicle. Data would be sent from the vehicle to an RSE unit. • Automated enforcement technologies identify vehicle type and mail citations to violators.	**Application 1: Dedicated Eco-Lanes** • Lane use control signs, static signs, and/or pavement markings indicate that *one lane is dedicated* for use by eco-friendly vehicles (e.g., low emission vehicles, high occupancy vehicles, transit vehicles, and designated freight vehicles). • Eco-lane systems utilize DSRC technology to determine whether the vehicles passing are eco-friendly vehicles. • Access to the eco-lanes would be based on real-time emission data collected directly from the vehicle. Data would be sent from the vehicle to an RSE unit. • Automated enforcement technologies identify vehicle type and mail citations to violators.

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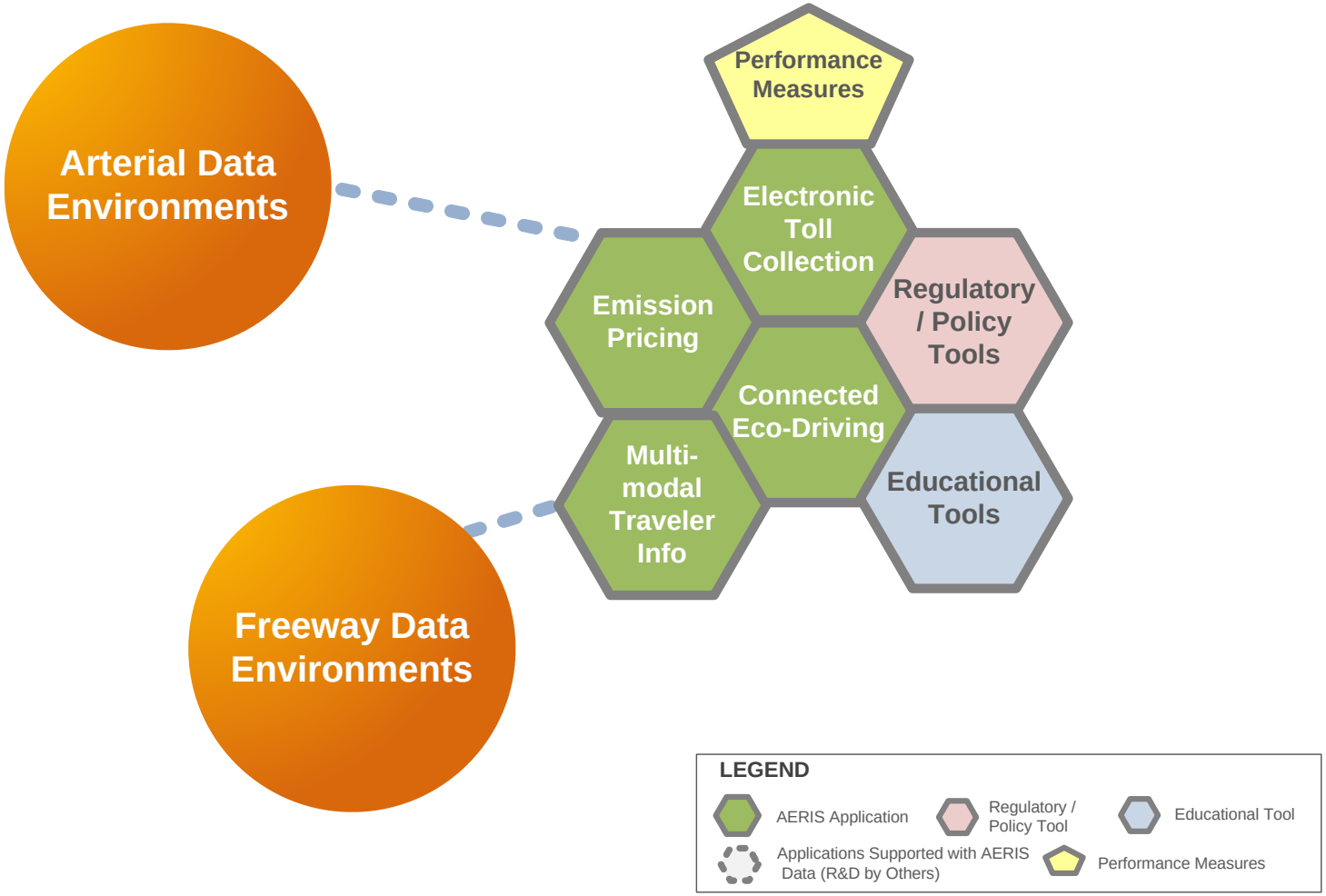
Application 2: Speed Harmonization • *One speed limit* is transmitted to *drivers in conventional lanes* via ITS devices (DMS and VSL signs) • *A different speed limit* (eco-speed limit) is transmitted to *drivers in eco lanes* via ITS devices (DMS and VSL signs) and in-vehicle systems (I2V). • Automated enforcement technologies identify speeding vehicles and mail citations to violators.	**Application 2: Speed Harmonization** • *One speed limit* is transmitted to *drivers in conventional lanes* via ITS devices (DMS and VSL signs) • *A different speed limit* (eco-speed limit) is transmitted to *drivers in eco lanes* via ITS devices (DMS and VSL signs) and in-vehicle systems (I2V). • The eco-speed limit is based on real-time emissions and data collected from vehicles. • In-vehicle systems provide drivers with eco-speed limits. • Automated enforcement technologies identify speeding vehicles and mail citations to violators.	**Application 2: Speed Harmonization** • *One speed limit* is transmitted to *drivers in conventional lanes* via ITS devices (DMS and VSL signs) • *A different speed limit* (eco-speed limit) is transmitted to *drivers in eco lanes* via ITS devices (DMS and VSL signs) and in-vehicle systems (I2V). • The eco-speed limit is based on real-time emissions and data collected from vehicles. • In-vehicle systems provide drivers with eco-speed limits. • Automated enforcement technologies identify speeding vehicles and mail citations to violators. **Application 3a: Eco-Adaptive Cruise Control** • Drivers of eco-friendly vehicles *retain control* of steering. • A subset of drivers in the eco-lanes uses eco-adaptive cruise control applications to automatically adjust their acceleration (throttle) and braking to control the speed of *each vehicle* in eco lanes.

TRANSFORMATIVE CONCEPT | Support AFV Operations



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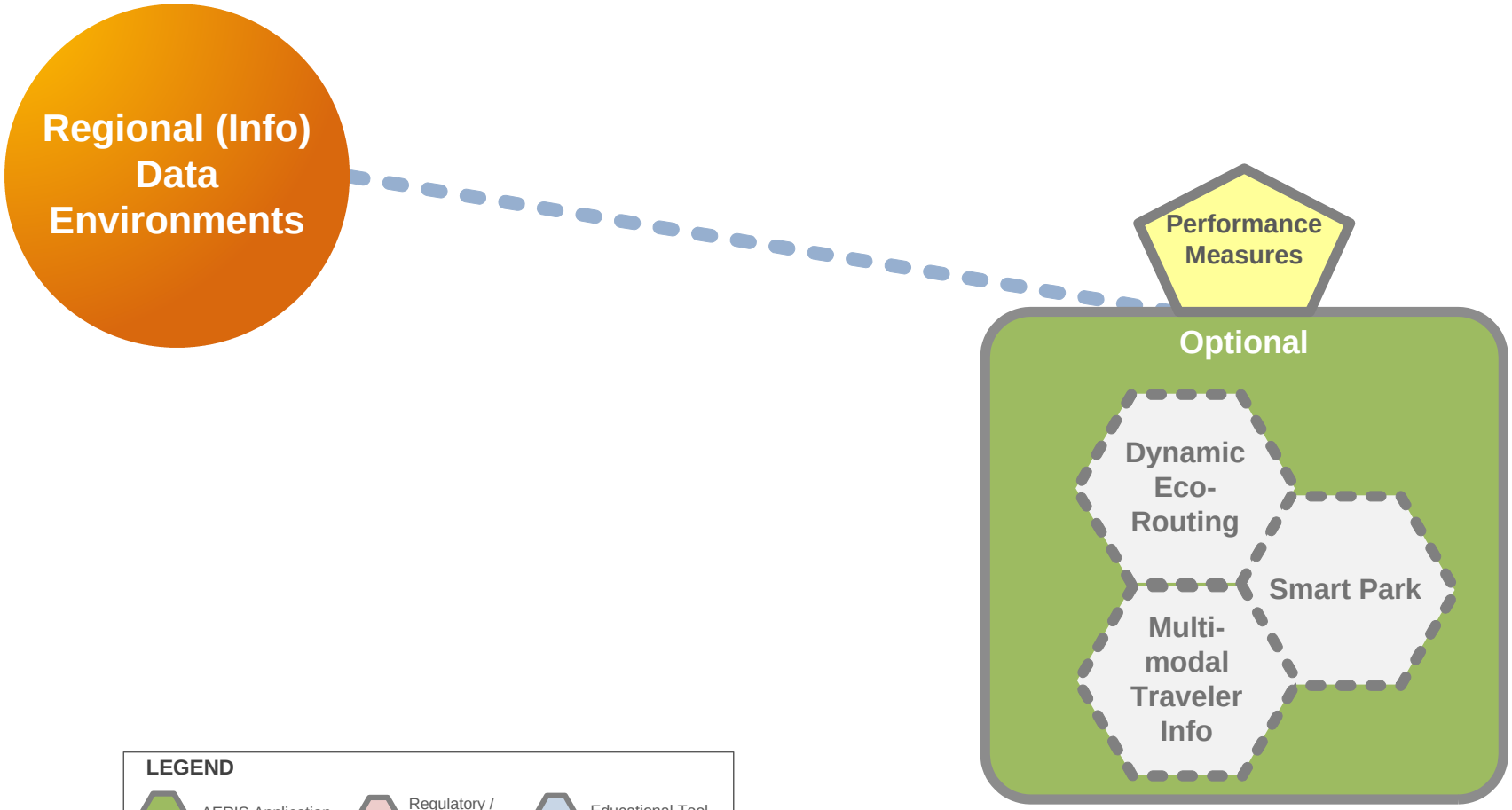

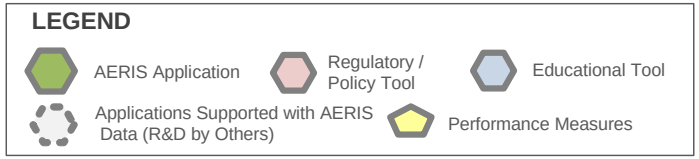

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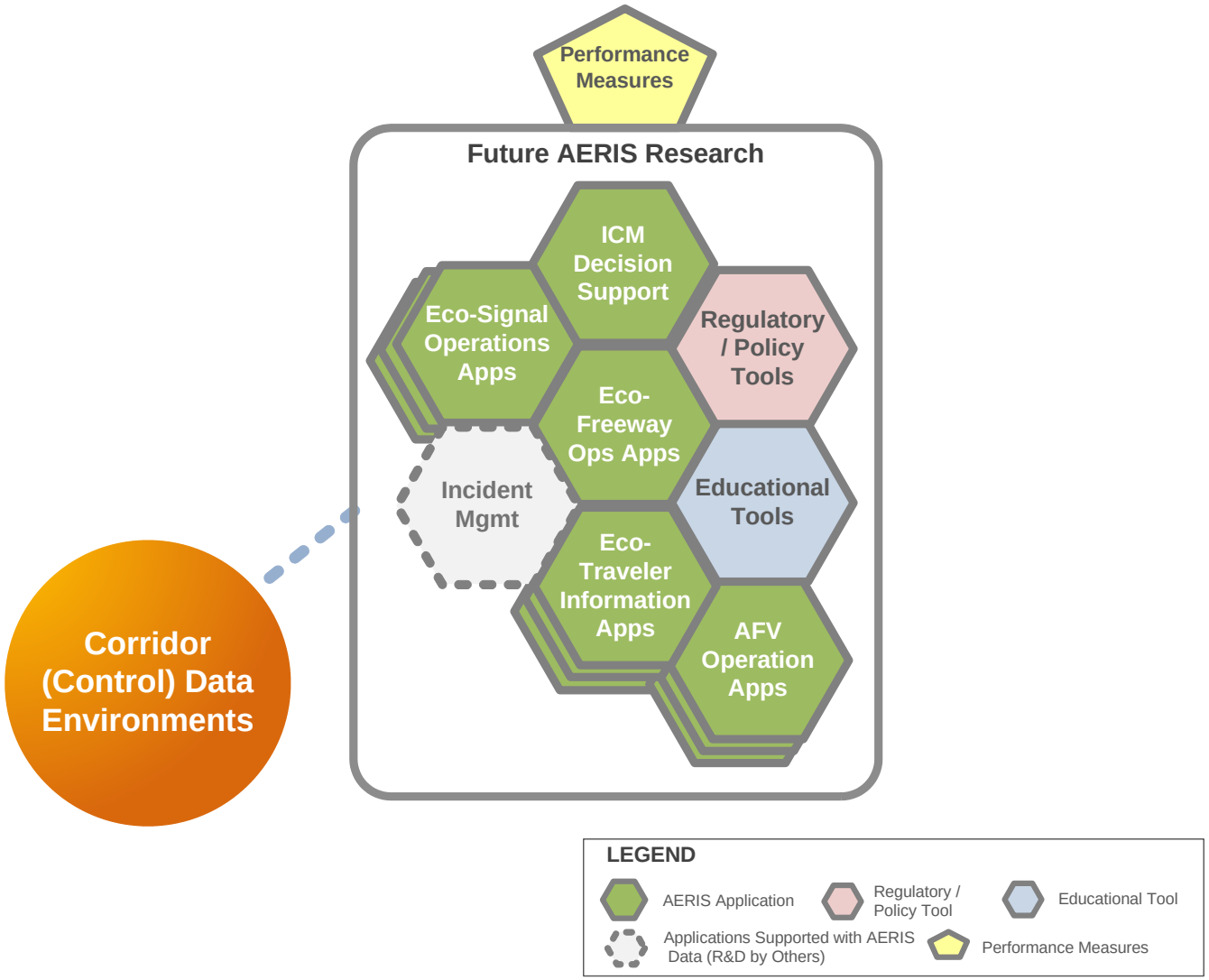

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