Breakout Session: Automated, Connected, Electric, Shared (ACES)

Florida Automated Vehicles Summit 2021

November 30, 2021

Trey Tillander, PE

Director, FDOT State Traffic Engineering & Operations Office

Speaker

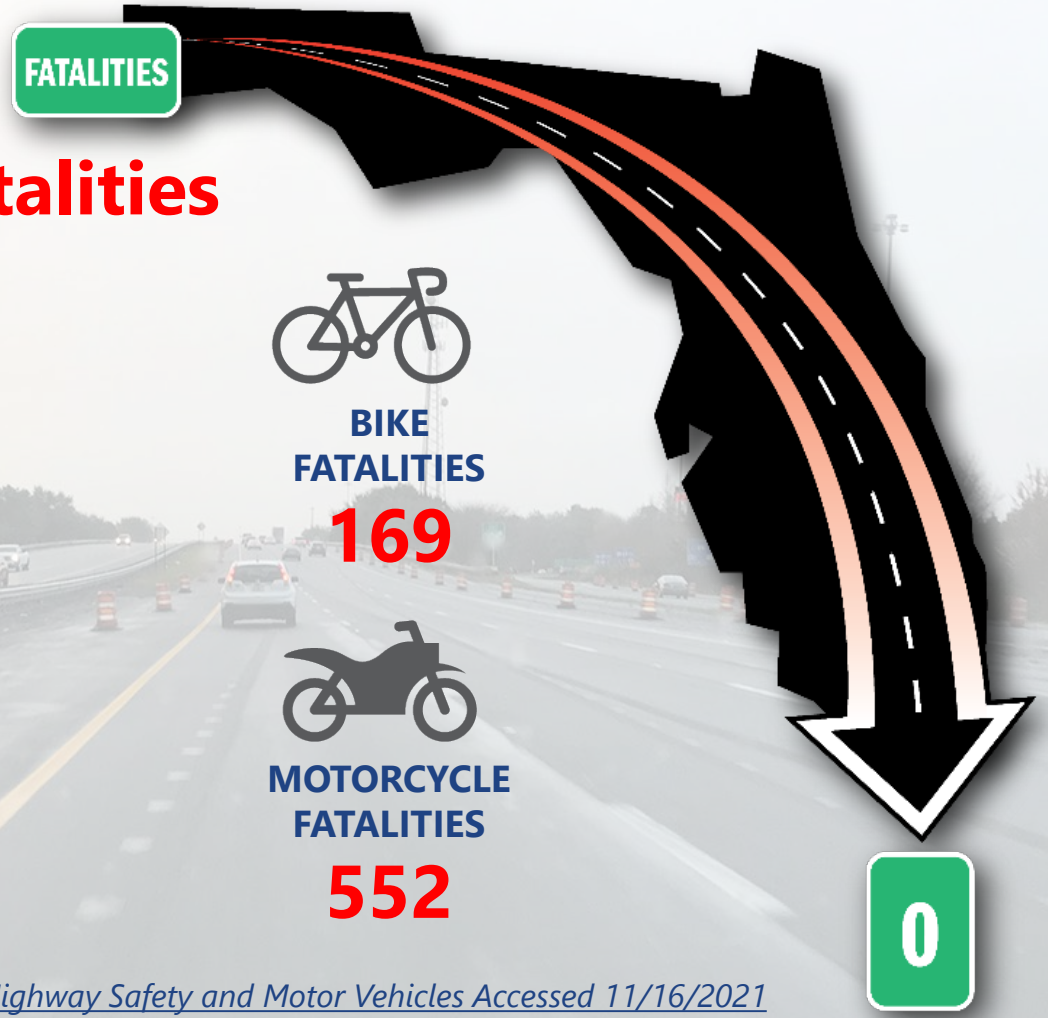
Mr. Raj Ponnaluri, PhD, P.E, PTOE, PMP
State Connected Vehicles, Arterials and
Managed Lanes Engineer

FDOT's Connected and Automated Vehicles Program

Florida's Connected and Automated Vehicle Program

Raj Ponnaluri, PhD, PE, PTOE, PMP
Connected Vehicles, Arterials, and Managed Lanes Engineer
FDOT Traffic Engineering and Operations Office

Vision Zero



2020 Fatalities

TRAFFIC FATALITIES
3,332

BIKE FATALITIES
169

PEDESTRIAN FATALITIES
715

MOTORCYCLE FATALITIES
552

Florida Department of Highway Safety and Motor Vehicles Accessed 11/16/2021

FDOT's Vital Few

Safety

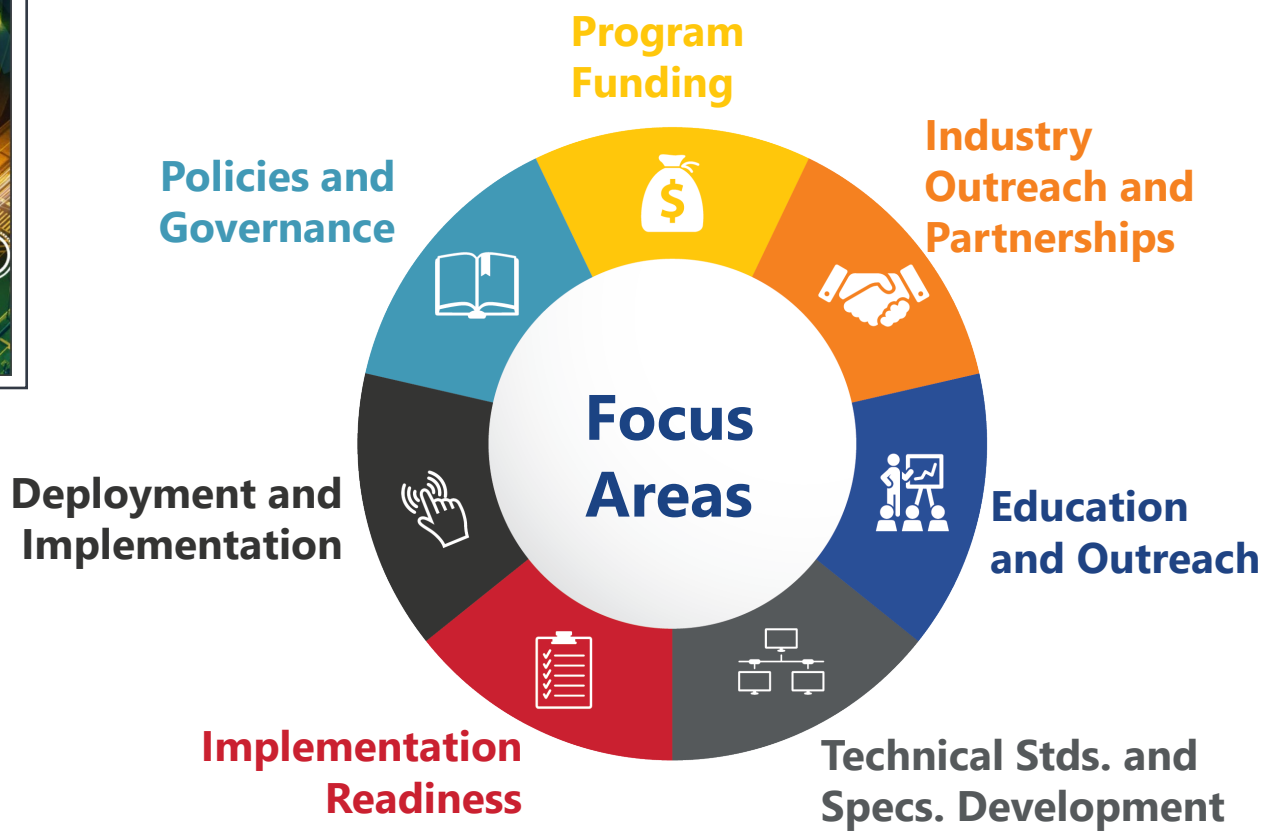
Mobility

Innovation

Workforce

The CAV Business Plan

FDOT's CAV Business Plan



Safety

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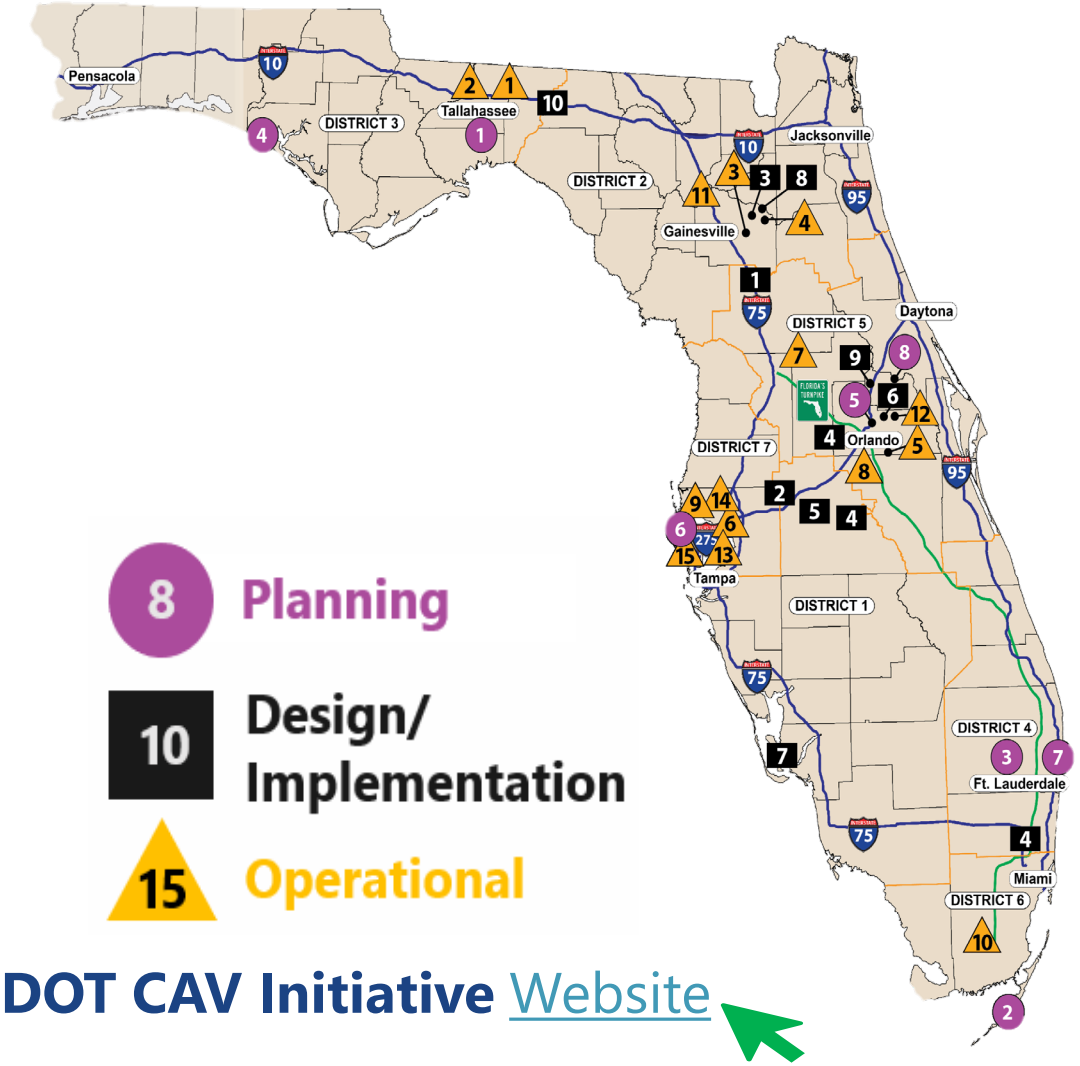
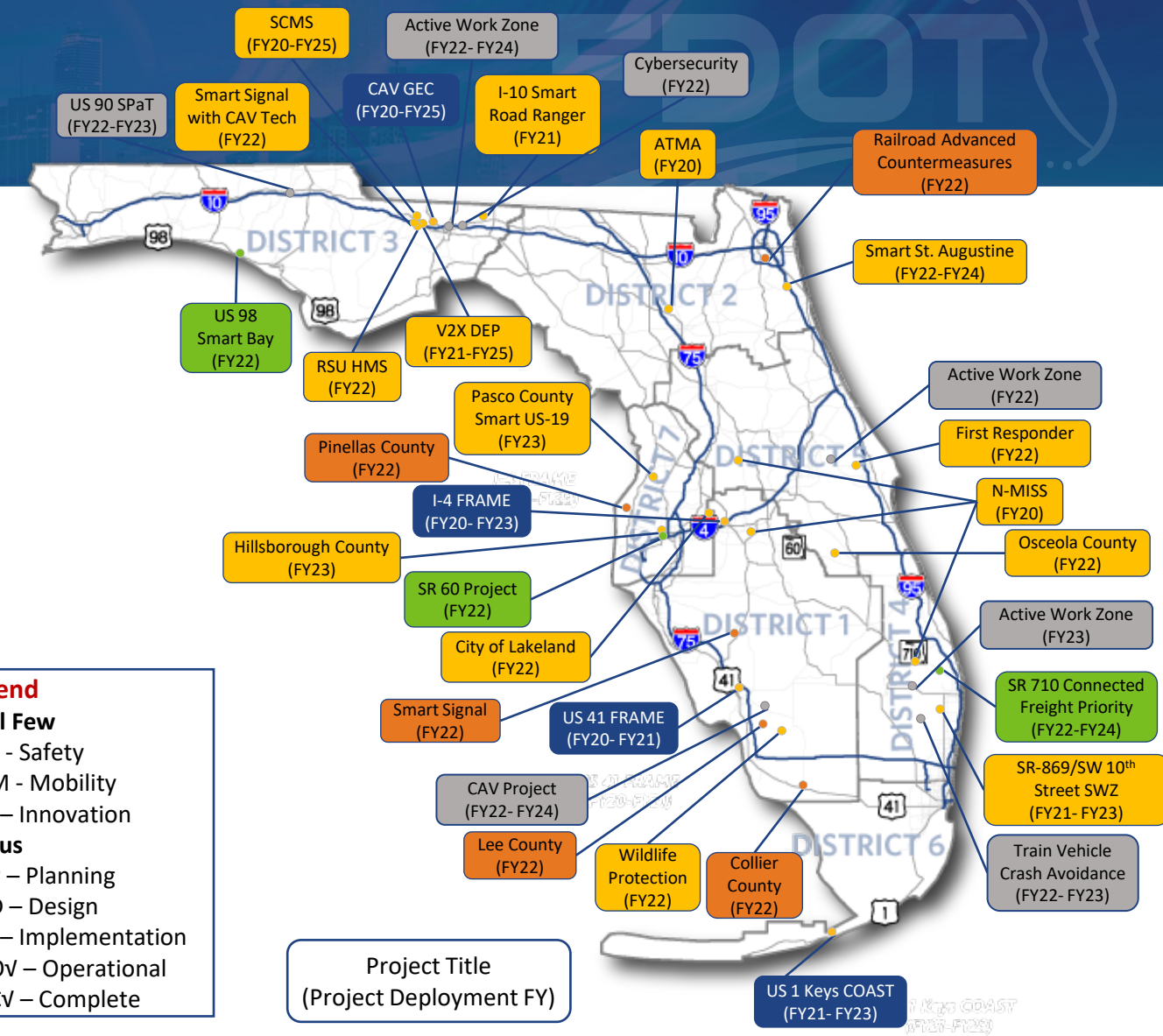


FDOT CAV Initiative Website

Approved in FY		Projects	District	Status
2018	1	I-4 FRAME	7,5,1	D
	2	US 41 FRAME	1	D
	3	CAV GEC	CO	OV
	4	US 1 Keys Connecting Overseas to Advance Safe Travel	6	D
2019	5	US 98- Smart Bay	3	P
	6	SR 60	7,5,1	D
	7	SR 710-Connected Freight Priority	4	P
2020	8	I-10 Smart Road Ranger	2	D
	9	Autonomous Truck-Mounted Attenuator	CO	CV
	10	Security Credential Management System	CO	OV
	11	Vehicle to Everything Data Exchange Platform (V2X DEP)	CO	D
	12	Near Miss Identification safety System	1,4,5	I
	13	Smart St. Augustine	2	P
	14	Hillsborough County CV Priority and Preemption System	7	P
	15	Intersection Collision Avoidance Safety	5	P
	16	SW 10th Street- SWZ	4	P
	17	CAV - Osceola County	5	OV
	18	Pasco County SMART US-19	7	P
	19	Wildlife Detection and Alert	1	P
	20	First Responder	5	I
	21	RSU Health Monitoring System	CO	P
	22	Smart Signal with CAV Tech.	CO	P
2021	23	Smart Signal	1	P
	24	Connected Traveler Information System	1	P
	25	US 41 CV Transit Signal Priority	1	P
	26	SR 60 West Coast Smart Signal Corridor	7	P
	27	Railroad Advanced Countermeasures	2	P
2022	28	Cybersecurity	CO	P
	29	Train Vehicle Crash Avoidance	4	P
	30	US 90 SPaT Tallahassee	3	P
	31	City of Sarasota	1	P
	32	Active Work Zone Management	CO	P
	33	Active Work Zone	4	P
	34	Active Work Zone	5	P



Legend

Vital Few
- S - Safety
- M - Mobility
- I – Innovation

Status
- P – Planning
- D – Design
- I – Implementation
- OV – Operational
- CV – Complete

Project Title
(Project Deployment FY)

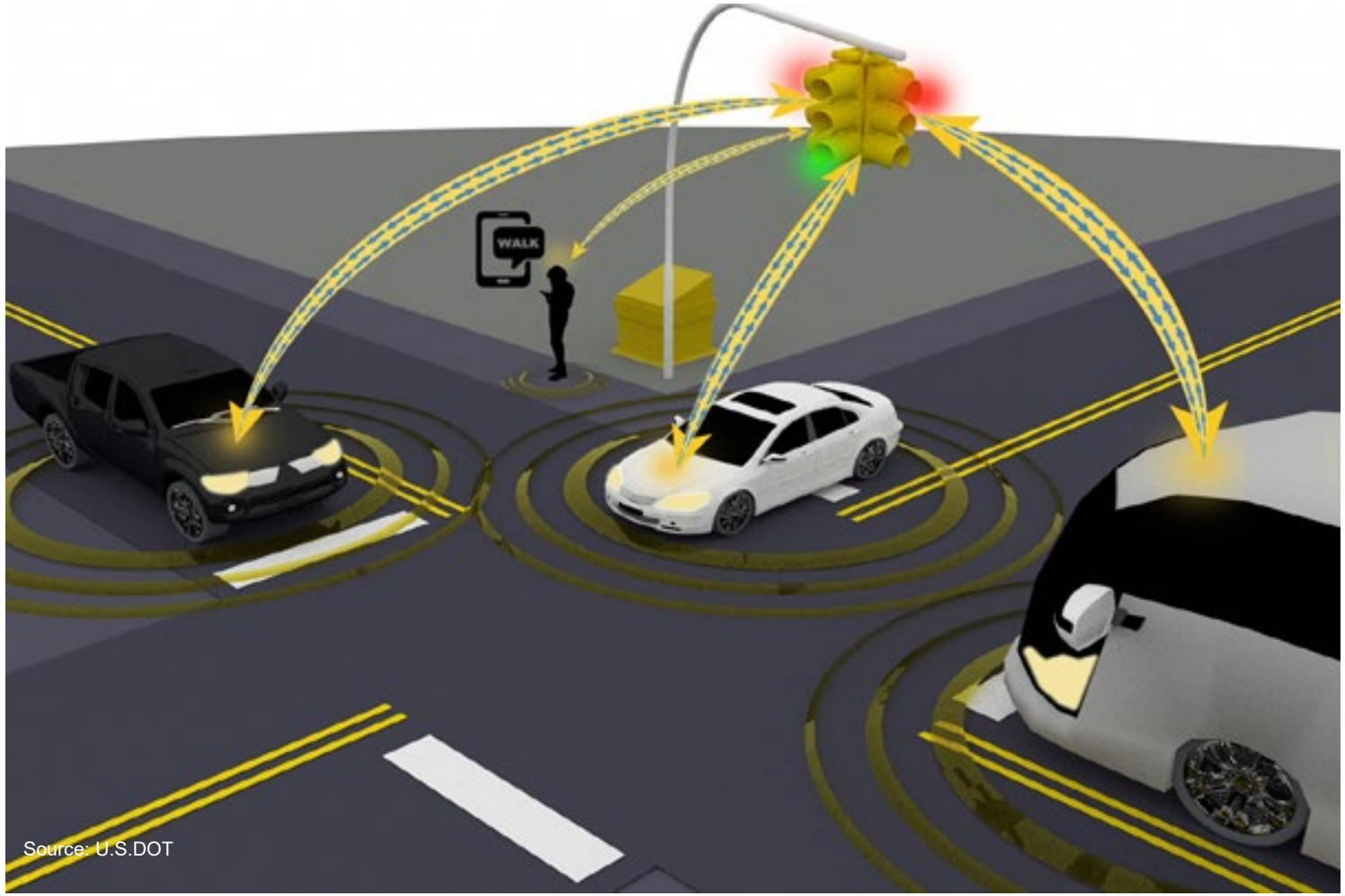
Communications and Applications

The three major approaches to communication:

- Vehicle to infrastructure, or V2I
- Vehicle to vehicle, or V2V
- Vehicle to pedestrian, or V2P

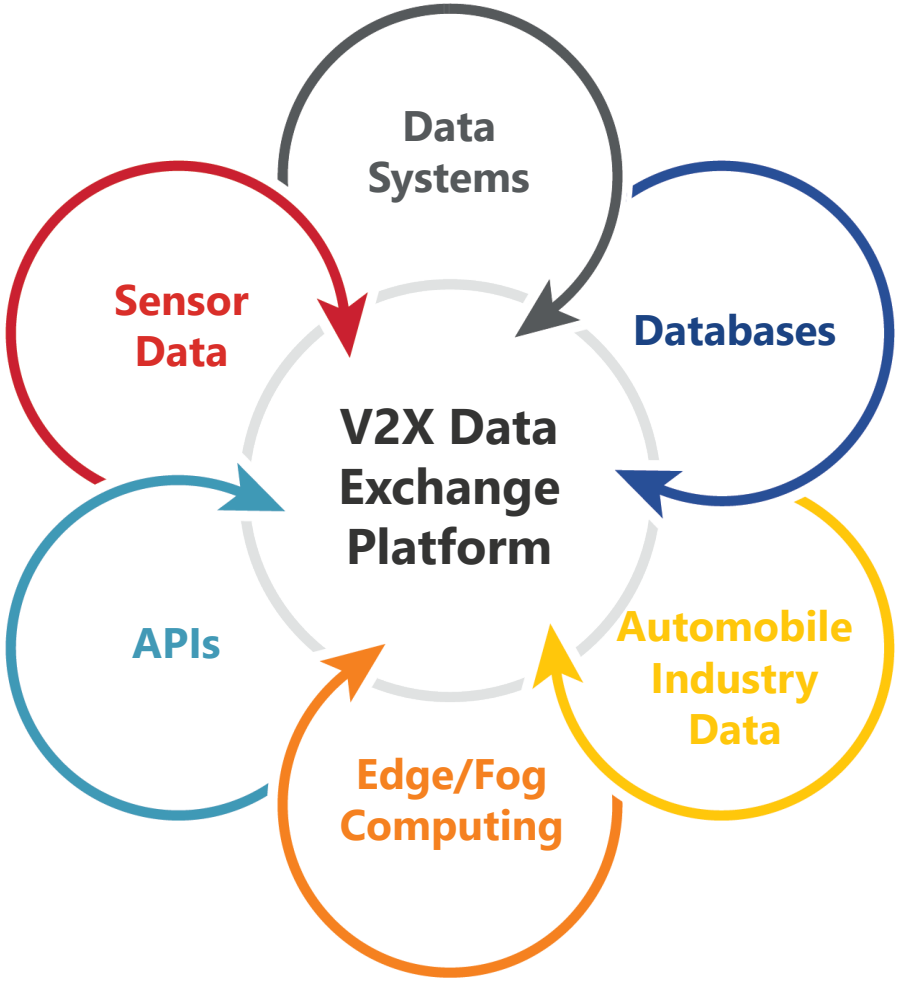
Applications:

- V2I safety applications
- V2V safety applications
- Environment Applications
- Mobility Applications
- Agency Operations Applications



How are **Security** and **Data Management** Addressed?

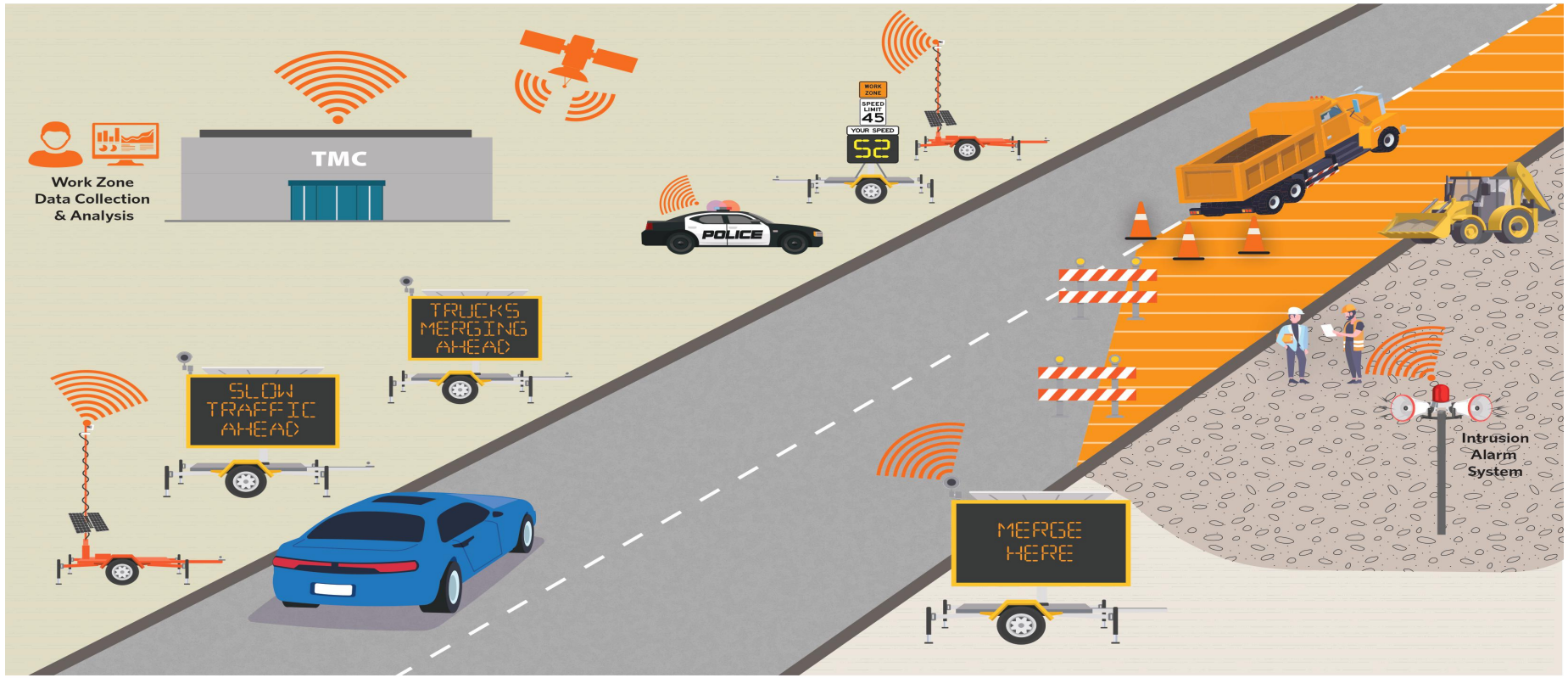
Security Credential Management System (SCMS) and Vehicle V2X Data Exchange Platform



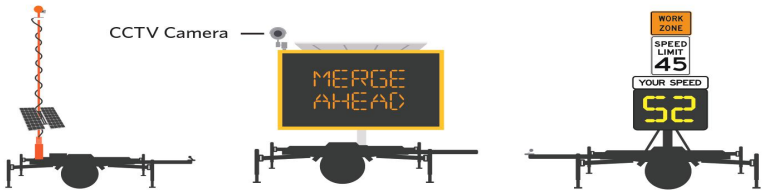
Innovation

Smart Work Zone (SWZ)

- Data Collection
- Real Time Data
- Automated Driving System
- Portable System
- Advanced Technology
- Reliable Information



LEGEND



ACTIVE WORK ZONE MANAGEMENT SYSTEM AND COMPONENTS

Dynamic Lane Merge System
- Traffic Detector
- Portable Changeable Message Signs

Construction Equipment Entering/Exiting System
- Traffic Detector
- Portable Changeable Message Signs
- Optional Signage (with Flashing Beacons)

Queue Warning System
- CCTV Camera
- Traffic Detector
- Portable Changeable Message Signs

Dynamic Speed Limit System
- Traffic Detector
- Speed Feedback Trailer

Travel Information System
- Traffic Detector
- Portable Changeable Message Signs

Work Zone Intrusion Alarms
- Traffic Detector
- Portable Changeable Message Signs
- Barriers
- Sirens or Horns

Near Miss Identification Safety System (N-MISS)

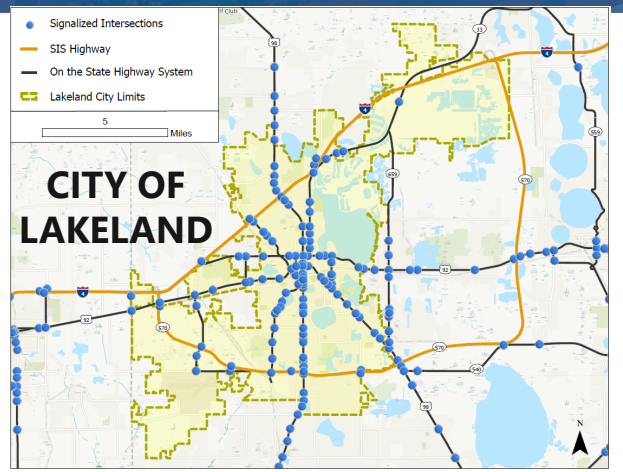
INNOVATION

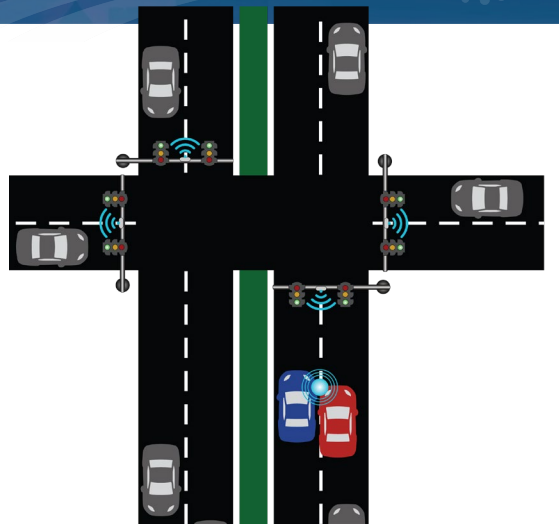
Major features:

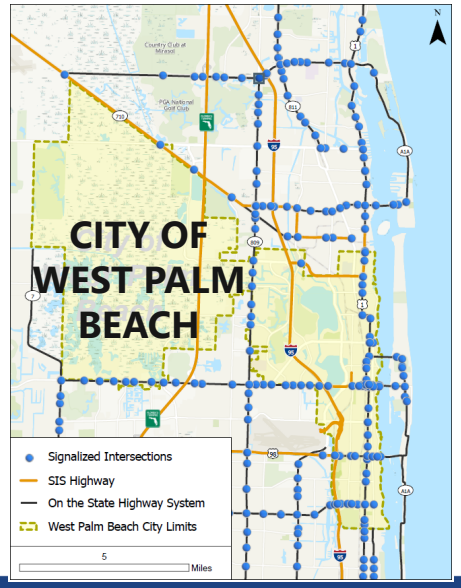
- 26 signalized intersections at City of Lakeland, Seminole County, and City of West Palm Beach
- Risk profiles based on near-miss events
- Collisions between oncoming vehicles, right-angle collisions, right-angle or side-swipe collisions, rear-end crashes.
- Real-time data
- Continuous Safety & Operations (CSO) Module and Diagnostic Risk Mitigation (DRM) Module

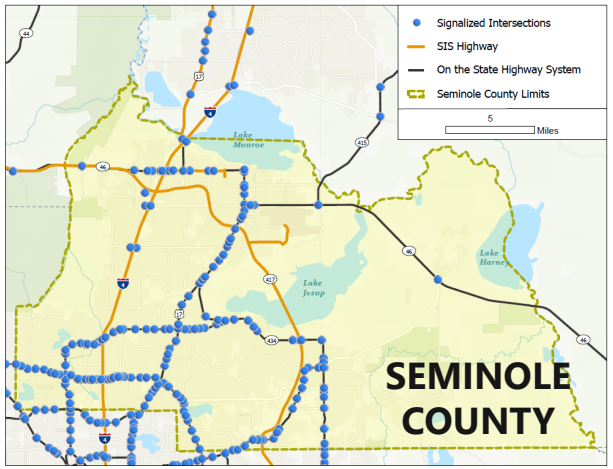
Benefits:

- Collect, analyze and disseminate real-time N-MISS information
- Developing application programming interfaces (APIs)
- Identify potential traffic incidents
- Reduce primary and secondary crash occurrences









CAV in Complete Streets

Characteristics of a **Complete Street**

Varies by context

Components

- *Sidewalks*
- *Bike Lanes*
- *Bus Lanes*
- *Transit Stops*
- *Frequent and Safe Crossings*
- *Median Islands*
- *Pedestrian Signals*
- *Curb Extensions Narrow Travel Lanes*
- *Parking*
- *More*

CAV approach to Complete Streets

Infrastructure Based

- Cyclist / pedestrian detection
- Dynamic signal technologies
- V2I applications
- Multi-use slow lanes
- Smart work zone / maintenance of traffic technologies
- Dynamic / managed lanes technologies

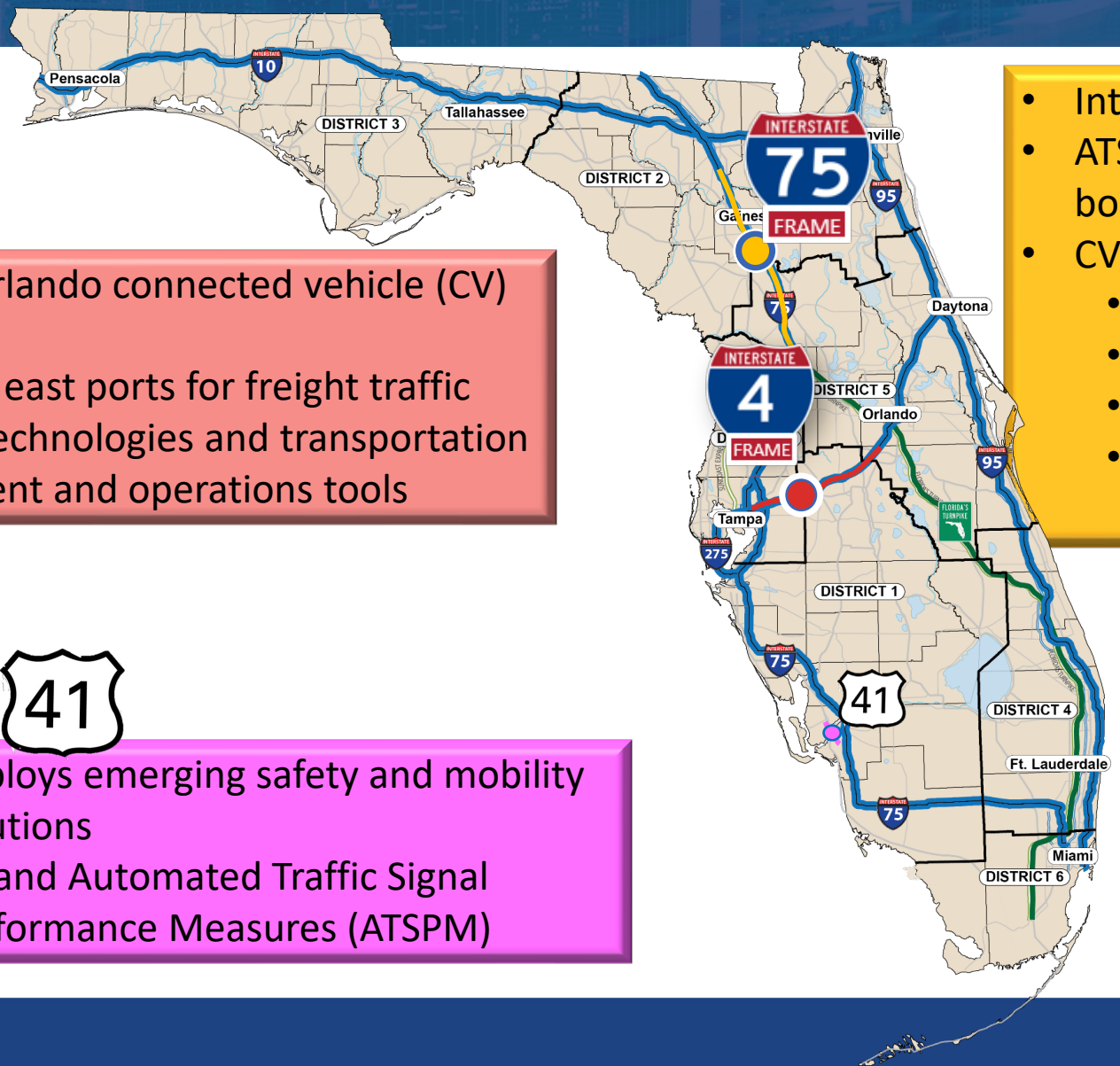
Vehicle Based

- AV / V2V applications

Ped/Bike/ Micromobility Based

- V2I / V2V applications
- AV applications

Multi-agency and Regional Systems



INTERSTATE 4 FRAME

- Links Tampa and Orlando connected vehicle (CV) projects
- Connects west and east ports for freight traffic
- Utilizes emerging technologies and transportation systems management and operations tools

41

- Deploys emerging safety and mobility solutions
- CV and Automated Traffic Signal Performance Measures (ATSPM)

INTERSTATE 75 FRAME

- Integrated corridor management (ICM)
- ATSPM, roadside units (RSUs), and on-board units (OBUs)
- CV applications deployed include:
  - Signal Phase and Timing (SPaT)
  - Transit Signal Priority (TSP)
  - Freight Signal Priority (FSP)
  - Emergency Vehicle Preemption (EVP)

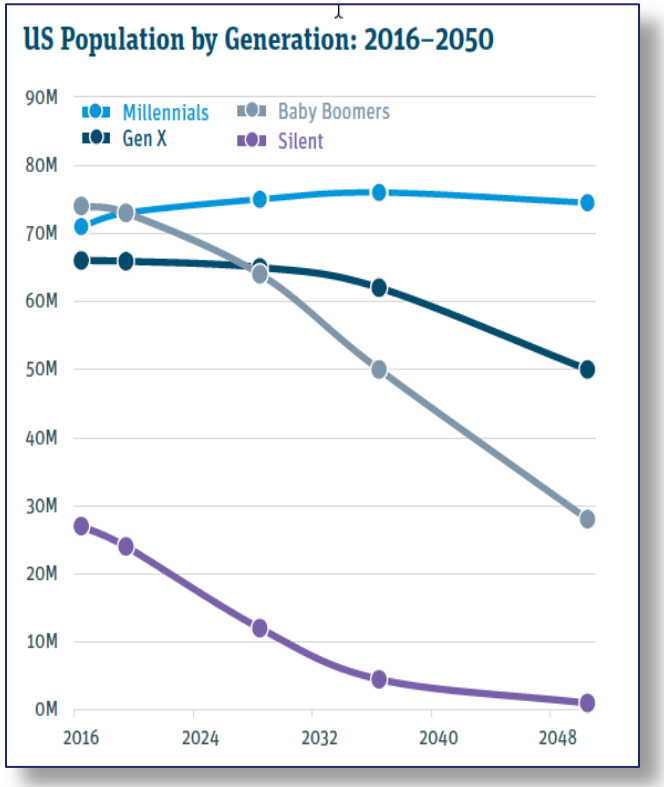
Electric Vehicle Master Plan

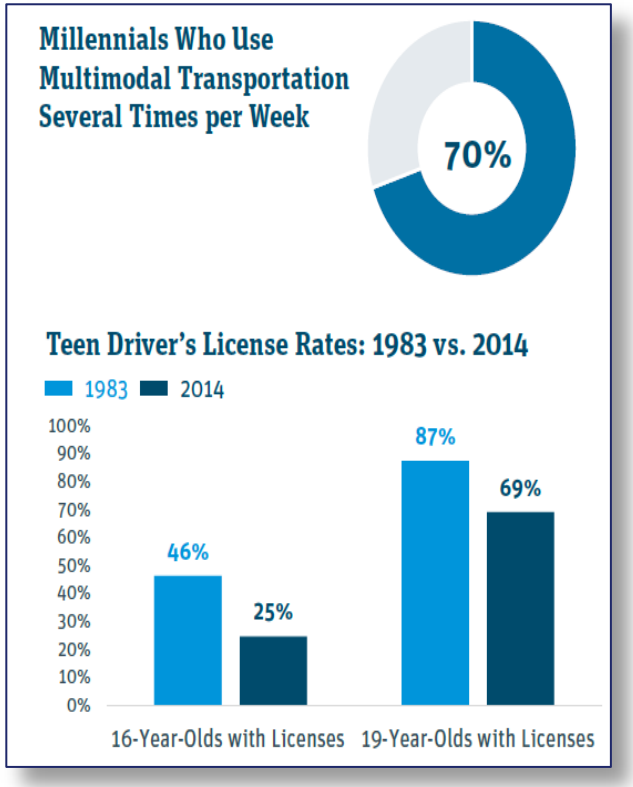
1. **Objectives of the plan:**
   - Support short- and long-range electric vehicle travel
   - Encourage the expansion of electric vehicle use in the state
   - Provide adequate evacuation routes in the state

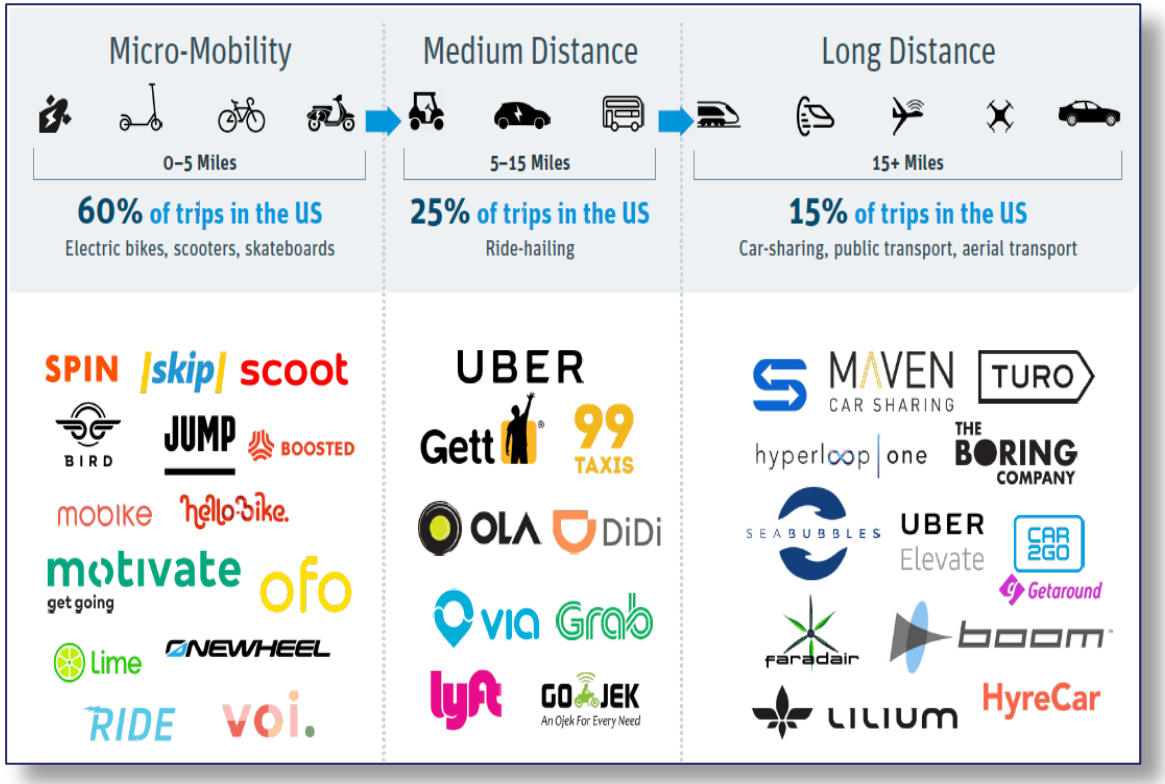
2. **Adoption Barriers**
   - EV cost parity with ICE vehicles
   - Lack of charging stations
   - No secondary market
   - Slow recharging times

3. **Focus Areas to increase EV adoption**
   - EV purchase instant rebate
   - Facilitate EV charging infrastructure at strategic areas
   - Consumer oriented education and outreach program
   - Interstate coordination and MOUs

Shared Mobility: Multimodal Transportation







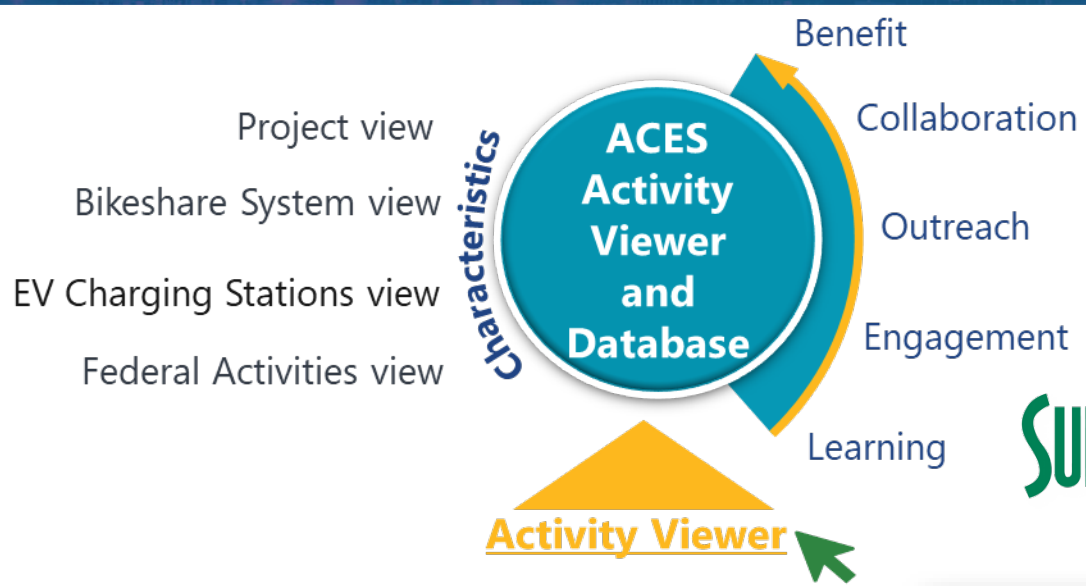
30% Of people in the US participate in Ride-Sharing

35% Of millennials globally are willing to car share

40M People will likely share vehicles by 2024

Source: PitchBook and SVB analysis

Micromobility and Multimodalism



SUNTRAX

Pod Cars/ Hoverboard

Florida ACES Transportation Roadmap

Personal Delivery Devices

- First and last mile connectivity
- Reduced congestion in urban areas
- Zero direct carbon emission

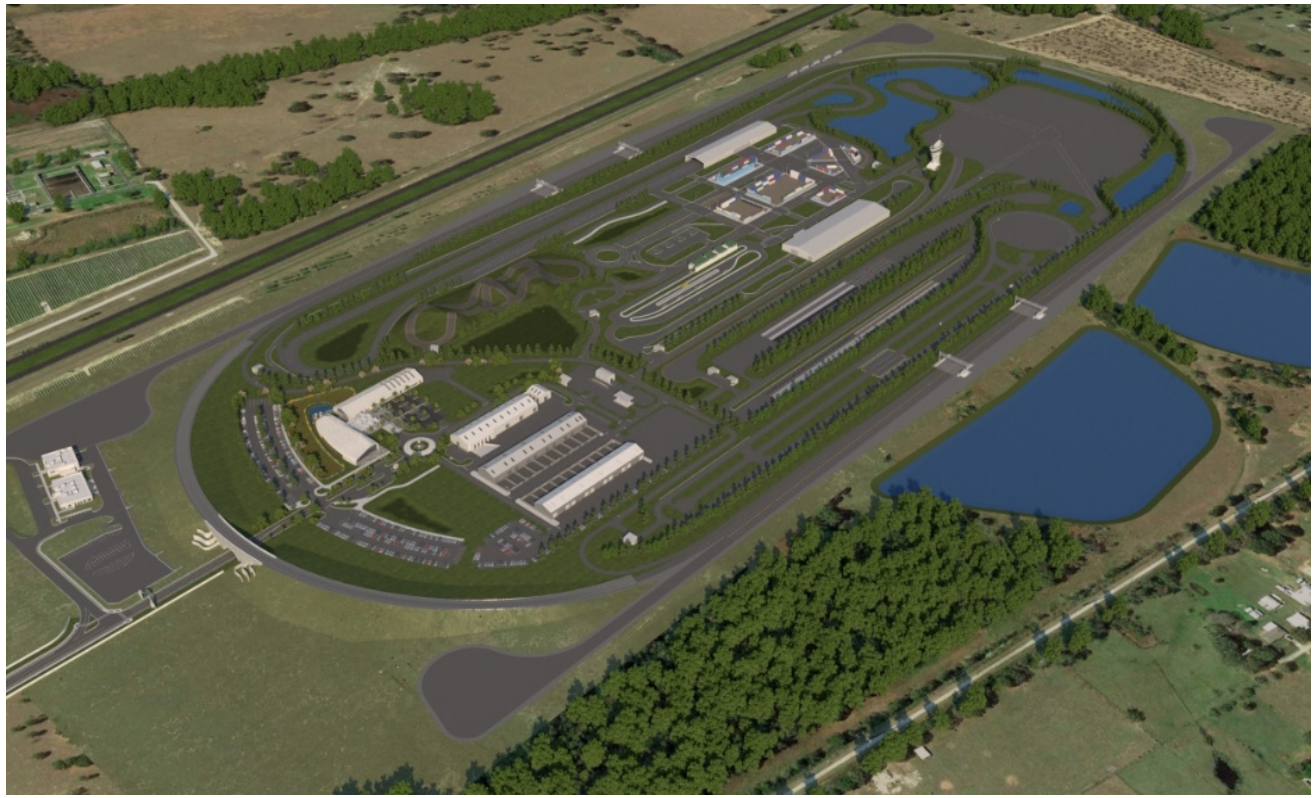
FDOT

SunTrax Test Facility

1. **Meet Department Technology Testing Needs**
   - Existing/New Toll Vendor Systems
   - Next Gen Tolling Systems, GPS, Mobile Apps
   - CV and Other Emerging, Transportation Technologies

2. **Enable Commercial CAV Technology Testing**
   - Improve Safety
   - Enhance Mobility
   - Reduce Congestion

3. **Expand Florida Research Activities and Capabilities**
   - Develop Research Projects
   - Disseminate Research Data
   - Develop Educational Programs



SunTrax

Implementing Solutions from Transportation Research and Evaluation of Emerging Technologies (I-STREET)

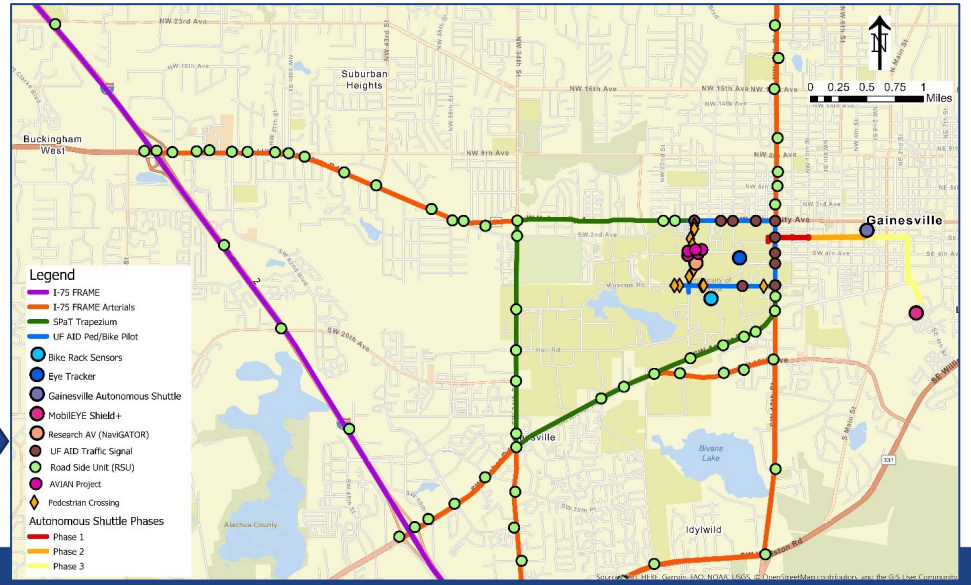
I-STREET

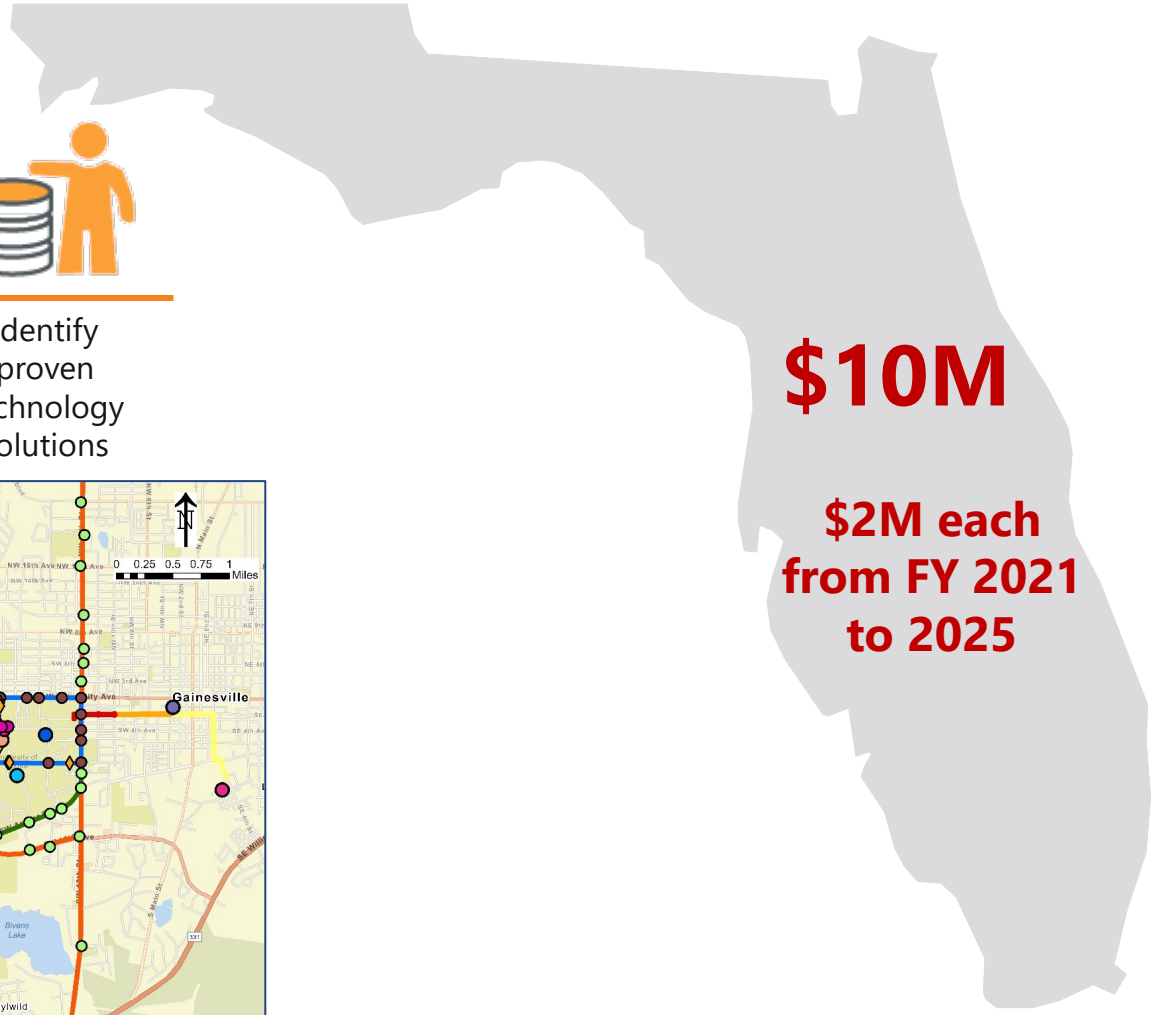
Demonstrate and test technology solutions

Provide test environments

Identify proven technology solutions

I-STREET Test Bed





$10M

$2M each from FY 2021 to 2025

Partnerships

Technology
Application
Partnership**s** for
Local **A**gencies

TAPs-LA

- Districts solicit proposals from local agencies
- Districts recommend projects to Central Office
- Central Office briefs TSM&O Leadership team
- FDOT leadership selects projects every year

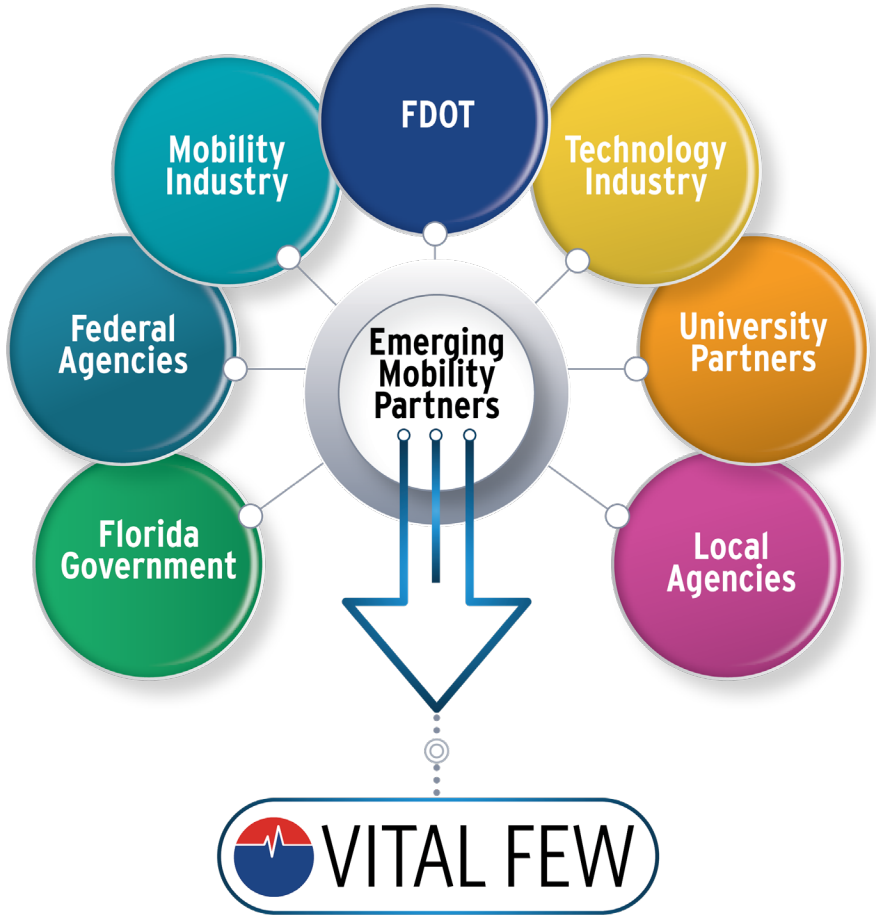
$10M

$2M each from FY 2021 to 2025

Assist local agencies with incorporating and deploying CAV technologies

Enable Local Agency Innovation

Florida Mobility Ecosystem



I-STREET

TRANSPORTATION INSTITUTE
UNIVERSITY OF FLORIDA

Thank you!

Raj Ponnaluri, PhD, P.E, PTOE, PMP
State Connected Vehicles, Arterials and Managed Lanes Engineer
Florida Department of Transportation

Speaker

Mr. Ronald Chin, P.E.
FDOT District 7 Traffic Operations Engineer

I-4 FRAME Connected Vehicles Deployment: What it means to the Region!

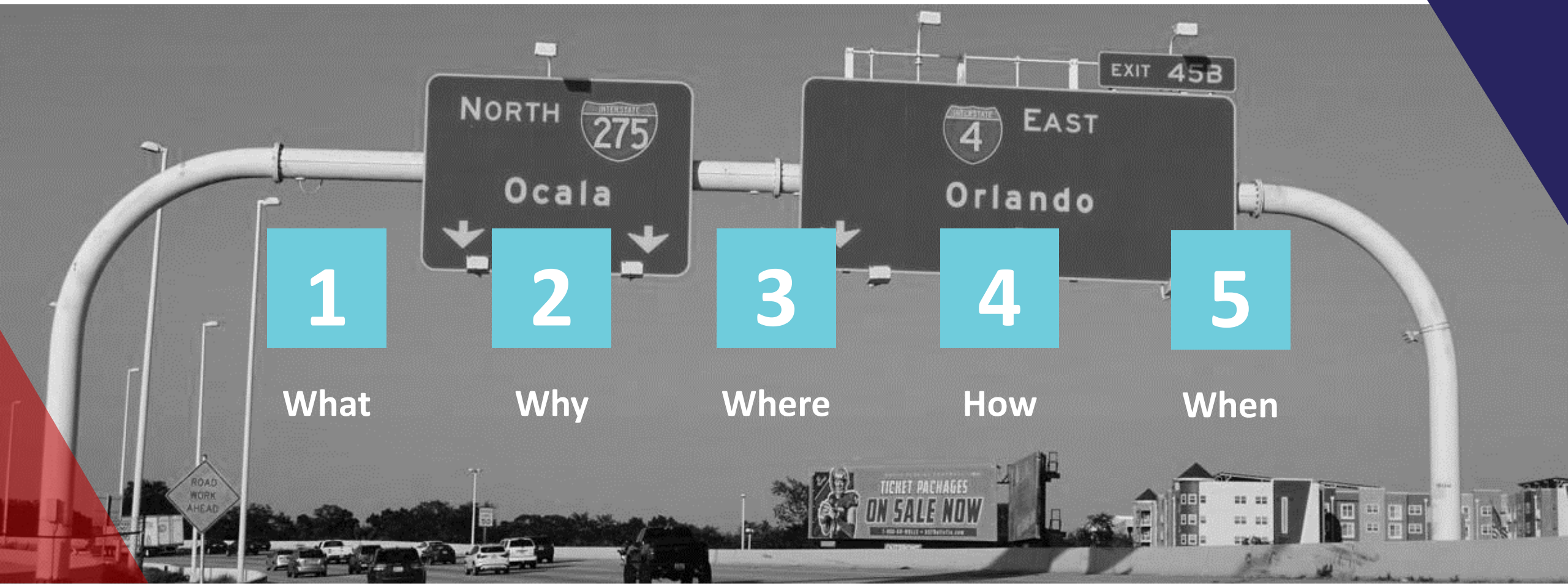
I-4 Florida's Regional Advanced Mobility Elements Project

FDOT Connected and Automated Vehicles Program

FDOT

UNDERSTANDING I-4 FRAME

I-4 Florida's Regional Advanced Mobility Elements Project



1 What

2 Why

3 Where

4 How

5 When

1 What is I-4 Florida's Regional Advanced Mobility Elements Project?

The Florida Department of Transportation's (FDOT) vision is to promote safety, mobility and innovation.

- FDOT developed the I-4 Florida's Regional Advanced Mobility Elements (FRAME) project to make your trip more reliable and safe.

- I-4 FRAME through **Connected Vehicle** (CV) and **Intelligent Transportation System** (ITS) technologies will allow vehicles to talk to traffic signals, other vehicles, etc.

2 Why do we need I-4 FRAME?

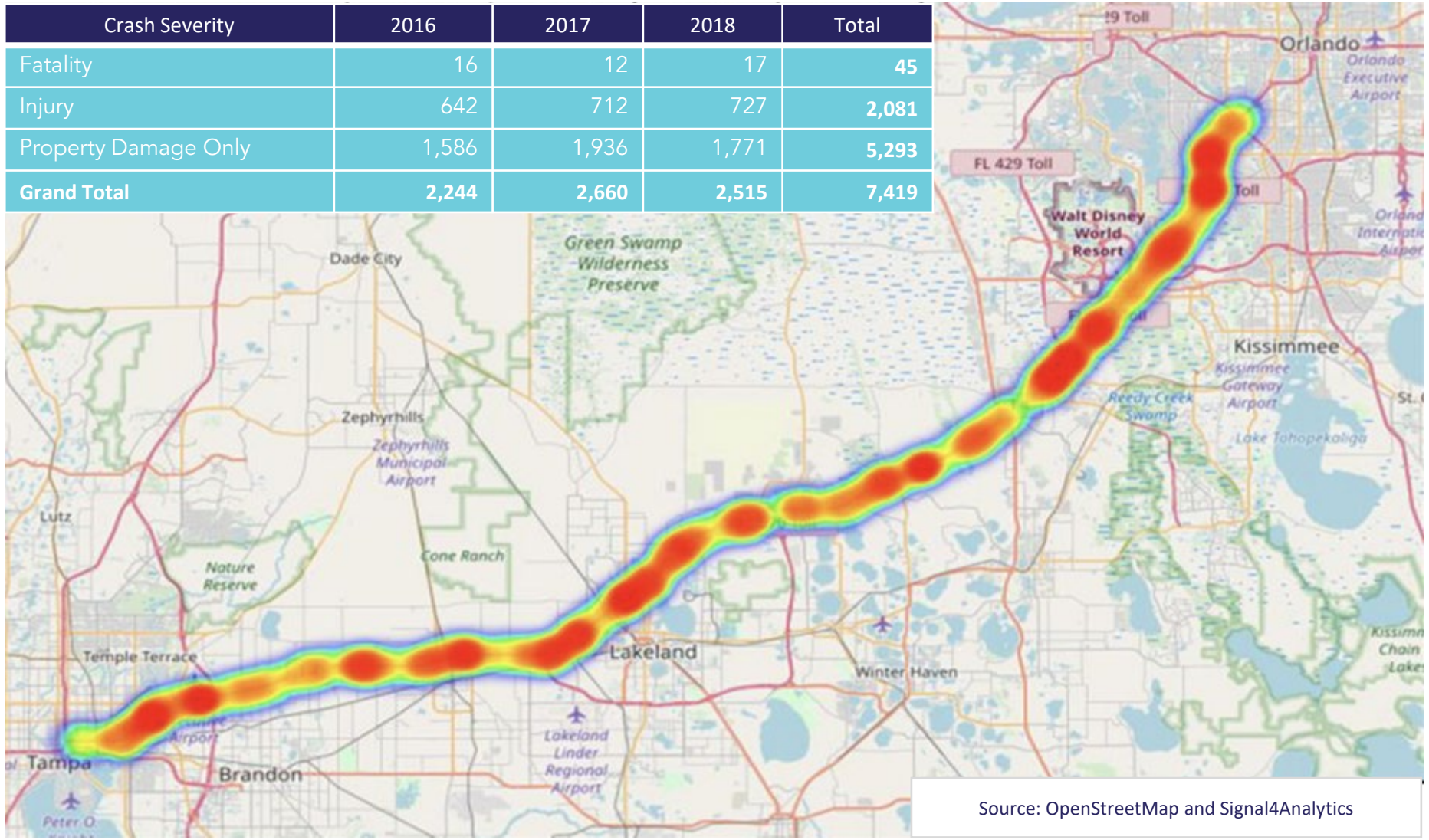
Interstate-4 (I-4) is a **vital artery** for economic activities in Florida, connecting the east and west coasts and the Tampa Bay and Orlando metropolitan regions.

Orlando received 75 million annual visitors in 2018 & is America's most visited destination.

- More than 150,700 vehicles traveling daily
- I-4 experiences severe mobility issues due to frequent crashes and recurring congestion.
- Between 2016 and 2018, **45 fatal crashes** and **2,081 injury crashes**.
- For the Traffic Homicide investigation, the average I-4 closure is 4 hours.
- I-4 averaged two lane-closure events per day
- **One full directional closure every 11 days in 2018**.

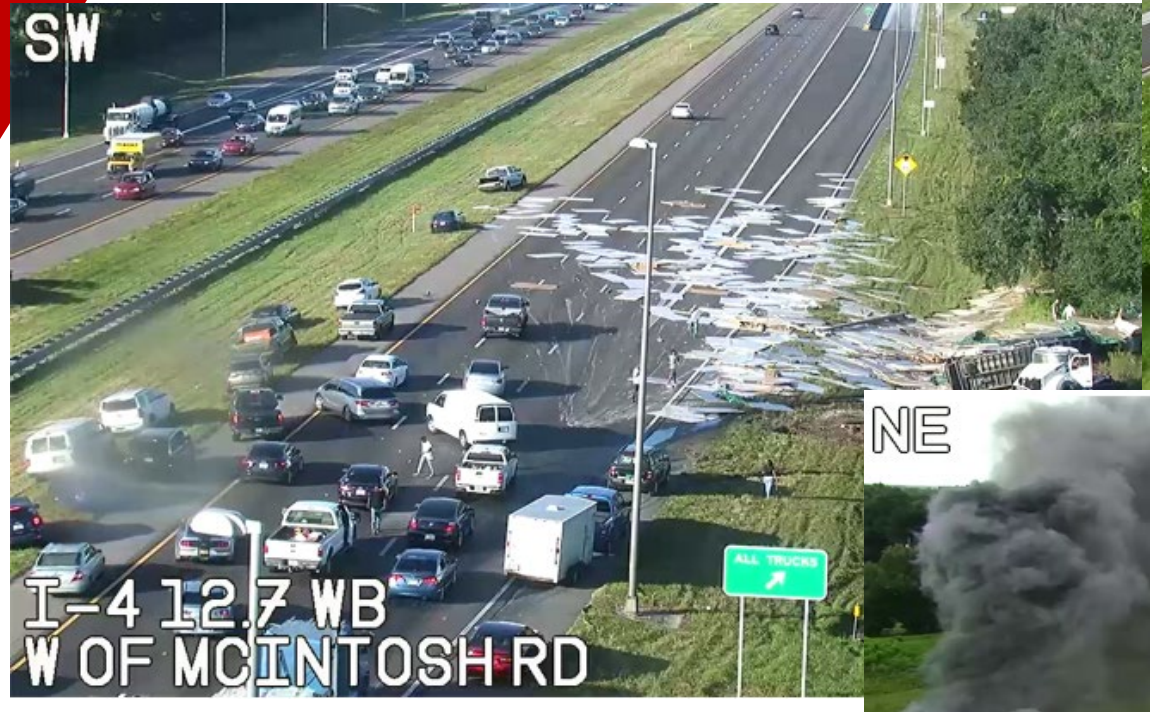
2 Why do we need I-4 FRAME?

Crash Severity	2016	2017	2018	Total
Fatality	16	12	17	**45**
Injury	642	712	727	**2,081**
Property Damage Only	1,586	1,936	1,771	**5,293**
Grand Total	**2,244**	**2,660**	**2,515**	**7,419**



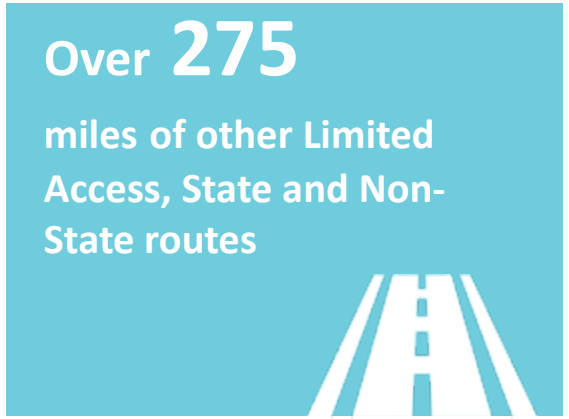
Source: OpenStreetMap and Signal4Analytics

2 Why do we need I-4 FRAME?

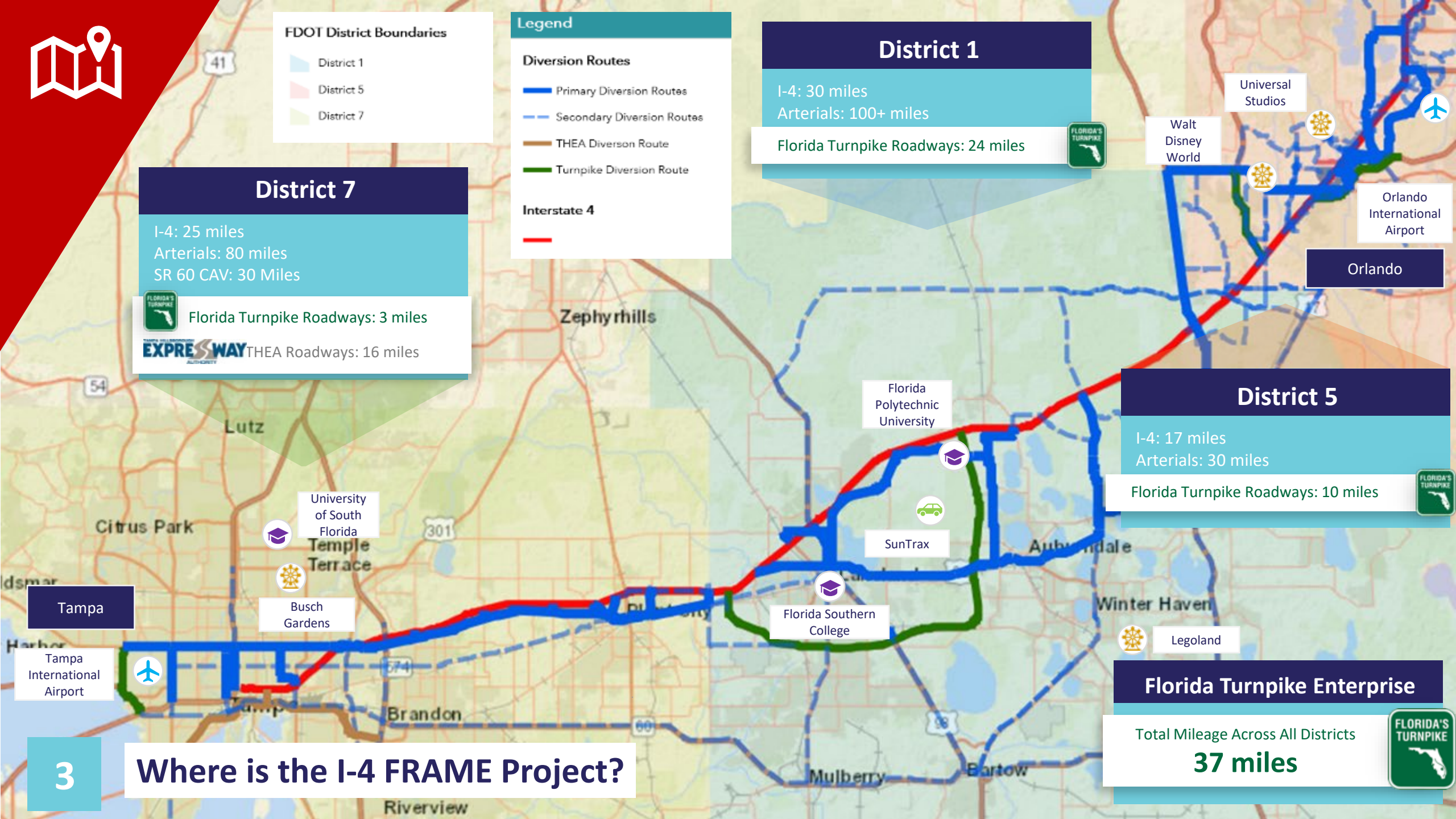


3 Where is the I-4 FRAME Project?

I-4 FRAME will improve safety and alleviate traffic congestion from Tampa to SW Orlando:



This project will bring FDOT closer to its vision of a fatality-free roadway network and a congestion-free transportation system in Florida using emerging technologies.



3

Where is the I-4 FRAME Project?

3 Where is the I-4 FRAME Project? Local Agency Stakeholders by District

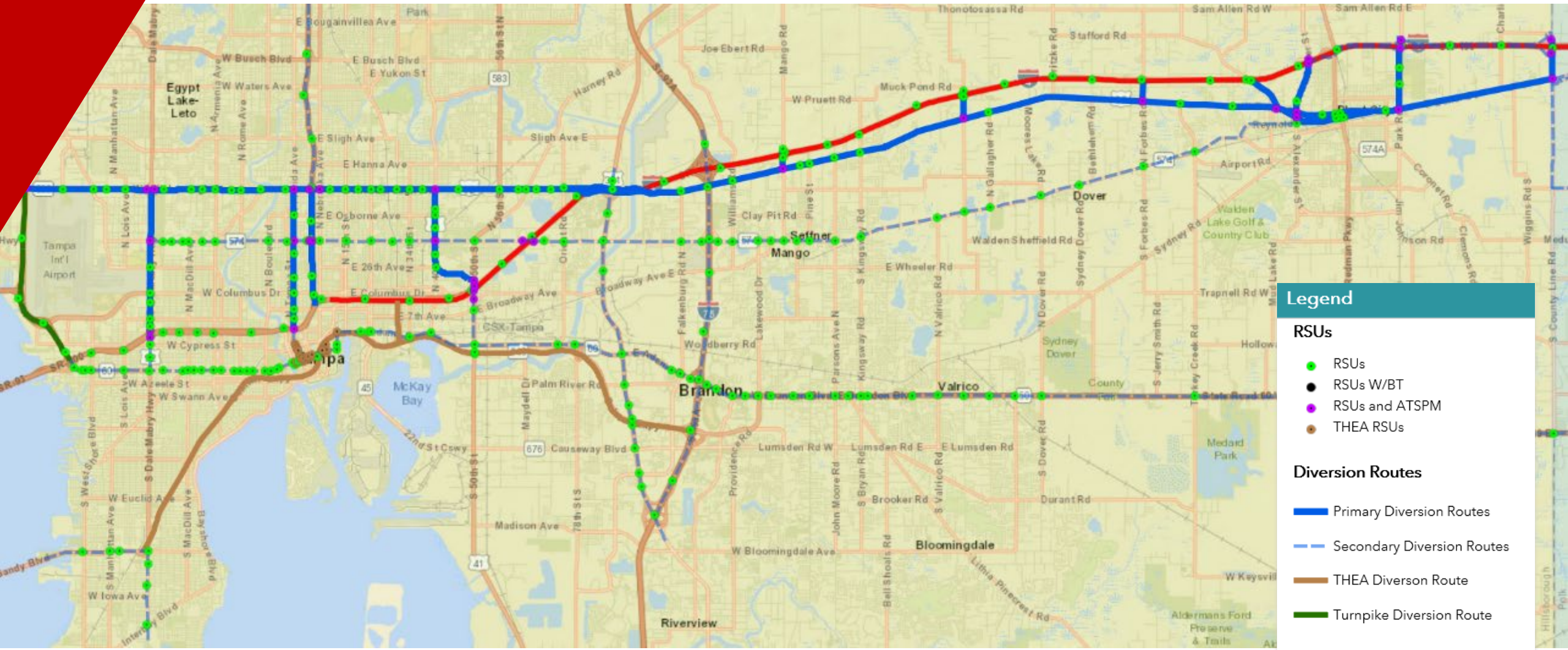
District 7	District 1	District 5
City of Tampa Hillsborough County City of Plant City	City of Lakeland Polk County City of Winter Haven	Orange County Osceola County

District 7

Florida Turnpike Roadways: 3 miles

THEA Roadways: 16 miles

I-4: 25 miles
Arterials: 80 miles



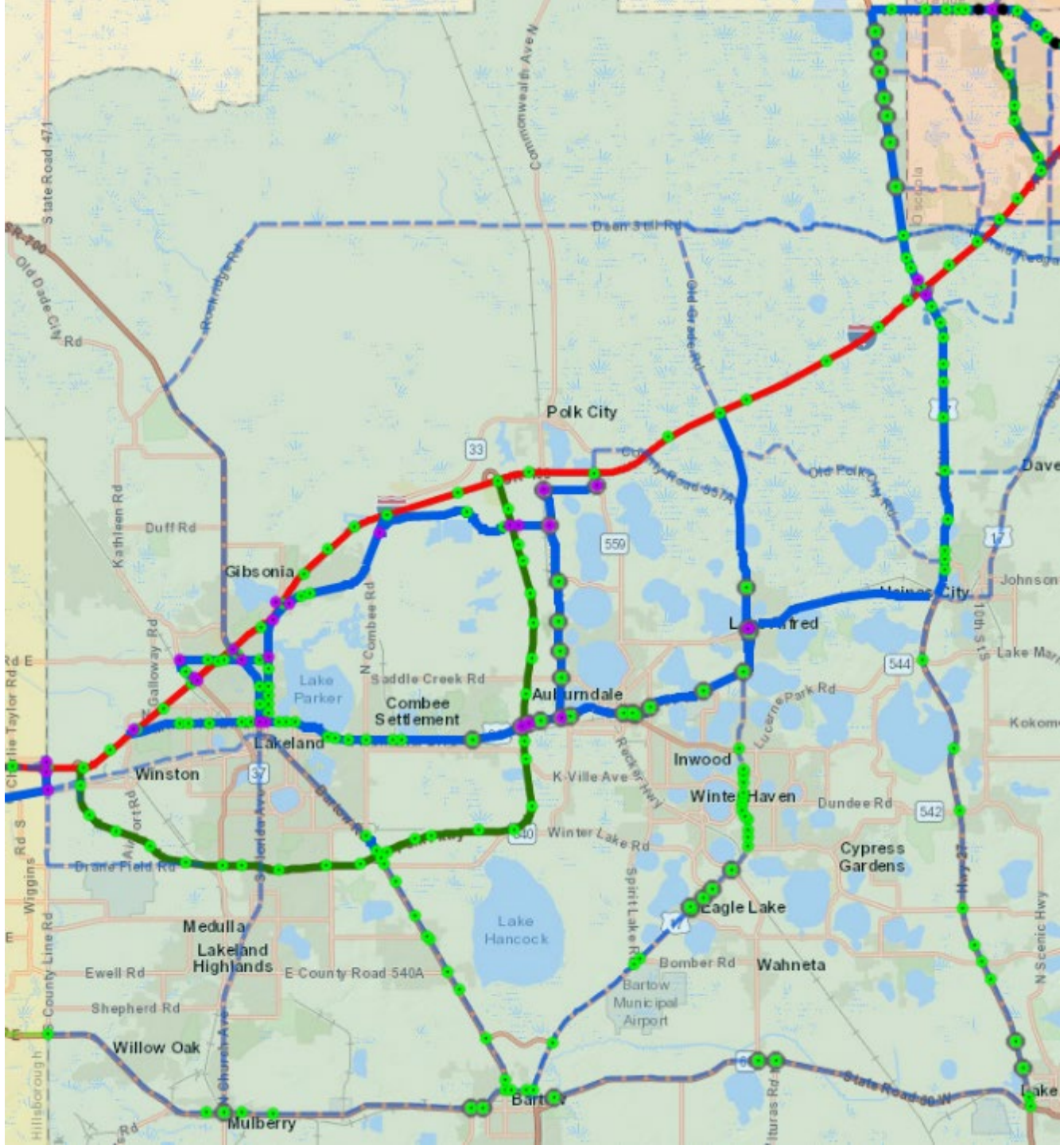
3

Where is the I-4 FRAME Project?

3

Where is the I-4 FRAME Project?

I-4 Florida's Regional Advanced Mobility Elements Project
FDOT Connected and Automated Vehicles Program



District 1

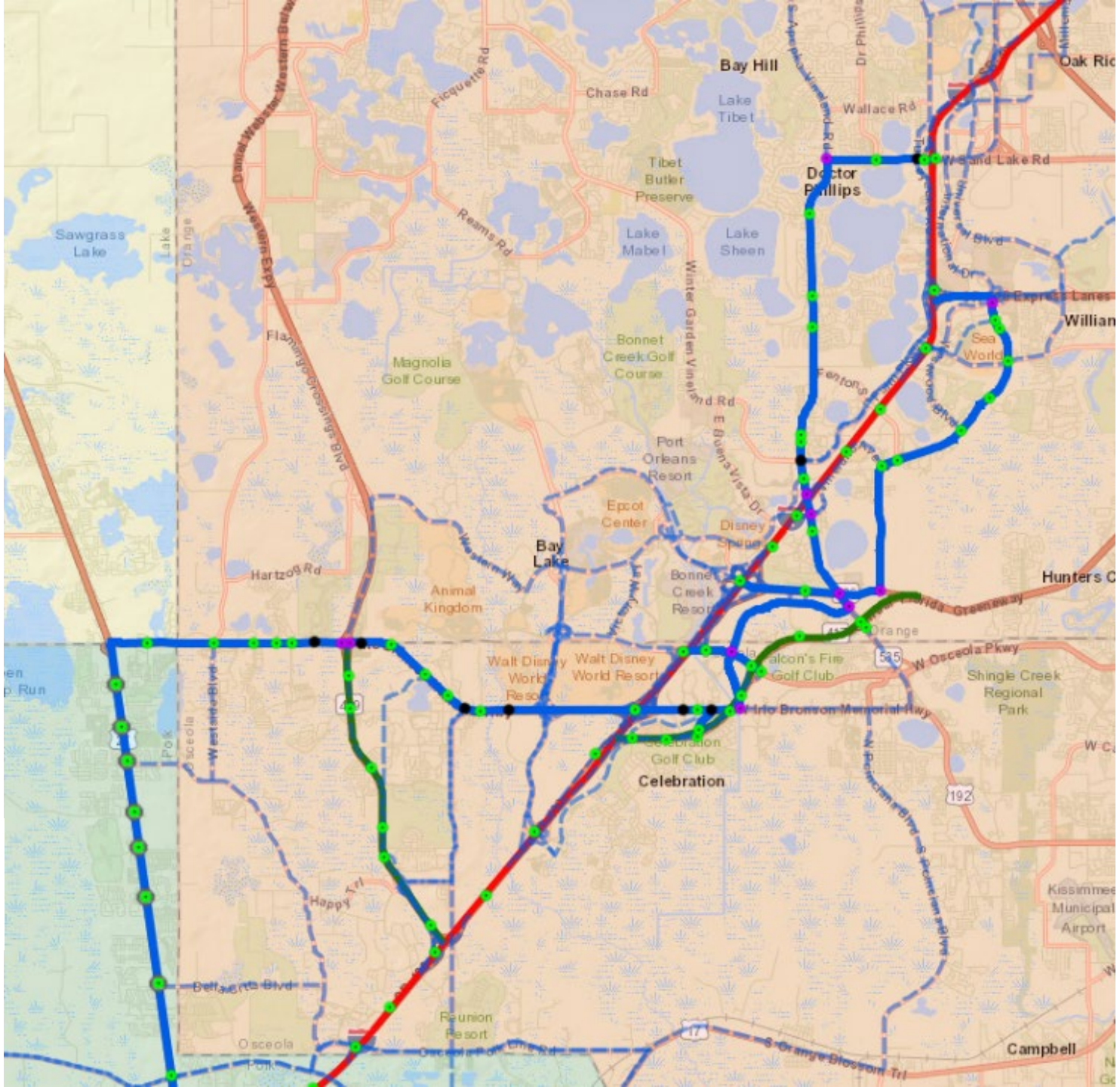
I-4: 30 miles
Arterials: 100+ miles

Florida Turnpike Roadways: 24 miles

3

Where is the I-4 FRAME Project?

I-4 Florida's Regional Advanced Mobility Elements Project
FDOT Connected and Automated Vehicles Program



District 5

I-4: 17 miles
Arterials: 30 miles

Florida Turnpike Roadways: 10 miles

Legend

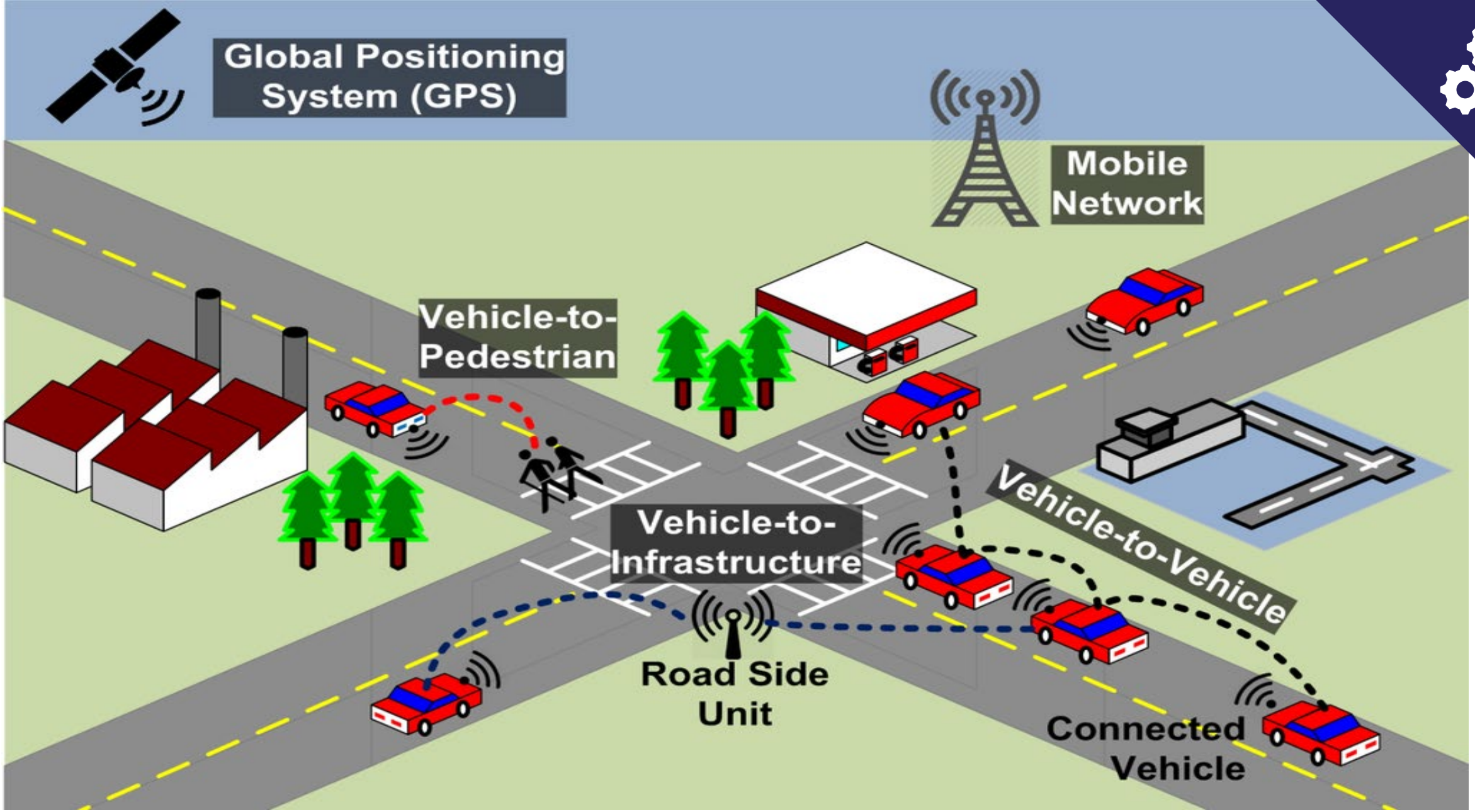
RSUs

- RSUs
- RSUs W/BT
- RSUs and ATSPM
- THEA RSUs

Diversion Routes

- Primary Diversion Routes
- Secondary Diversion Routes
- THEA Diverson Route
- Turnpike Diversion Route

Interstate 4



4 How does I-4 FRAME work?

Source: www.mdpi.com

4 How does I-4 FRAME work?

HARDWARE – CV TECHNOLOGIES

Roadside Units (RSU)

- Wireless communication between the roadway infrastructure and the vehicles that are equipped with OBUs
- Communicates on the 5.9 GHz DSRC band or C-V2X to transmit and receive CV messages

On-board Units (OBU)

- Device installed on the motor vehicle to allow communication (transmitting/receiving) with other OBUs or RSUs

Integrated V2I Prototype (IVP) Hub

- A small form-factor computer
- Handles the processing of CV applications
- Allows the RSU to perform “radio” functions only
- Only being installed at locations with Passive Pedestrian Detection (3 locations)

4 How does I-4 FRAME work?
CV Applications - Freeway

➢ Traffic Incident Management (TM08)

Broadcast traffic incident management information from incident detection, maintenance and construction management, and emergency/evacuation management centers.

➢ Dynamic Roadway Warning (TM12)

Broadcast information on back-of-queues, roadway hazards, road weather conditions, road surface conditions, and obstacles in the road

➢ Speed Warning and Enforcement (TM17)

Broadcast vehicle speed advisories to warn drivers of reduced speed recommendations based on roadway conditions ahead

➢ Dynamic Route Guidance (TI03)

Broadcast information on advanced route planning and guidance that is responsive to current traffic conditions

➢ Queue Warning (VS08)

Broadcasts back-of-queue warnings to minimize or prevent rear-end or other secondary collisions.

➢ Incident Scene Safety Monitoring (PS07)

Broadcasts messages to alert drivers of incident zone operations.

➢ Reduced Speed Zone Warning/Lane-Closure (VS09)

Broadcasts information on reduced speed zones including construction/work zones and road weather.

➢ Work Zone Management (MC06)

Broadcasts safety advisories to motorists in areas where maintenance, construction, and utility work are ongoing.

➢ In-vehicle Signage (TI07)

Augments regulatory, warning, and informational signs and signals by providing information directly to drivers through in-vehicle devices.

➢ Road Weather Motorist Alert and Warning (VS07)

Transmits environmental sensor data via the RSUs to warn drivers of any weather-related issues

4 How does I-4 FRAME work?
CV Applications - Arterial

➢ Connected Vehicle Traffic Signal System (TM04)

Use CV Data to adjust signal timing for an intersection or group of intersections to improve traffic flow. Application will analyze current conditions based on BSM data from OBUs.

➢ Transit Signal Priority (PT09)

Use CV Data to improve the operating performance of the transit vehicles by reducing the time spent stopped at a red light. Will use transit V2I communications to allow transit vehicles priority.

TSP Locations are limited to existing TSP locations within D5 at this time and filling in gaps along those routes. Conversations with HART are ongoing and an AVL/OBU Solution is being investigated as they plan on upgrading their AVL system soon.

➢ Emergency Vehicle Preemption (PS03)

Use CV data to improve the operating performance of emergency vehicles by facilitating the movement of public safety vehicles the intersection. Will use emergency vehicle V2I communications to allow emergency vehicles priority.

➢ Freight Signal Priority (CVO06)

Use CV Data to reduce stops and delays for increased travel time reliability for freight traffic and for enhancing safety and intersections. This will be deployed along the SR 60 corridor.

➢ In-vehicle Signage (TI07)

Augments regulatory, warning, and informational signs and signals by providing information directly to drivers through in-vehicle devices.

➢ Pedestrian and Cyclist Safety (VS12)

Sensing and warning systems used to interact with pedestrians, cyclists, and other non-motorized users will be deployed at select locations. It will integrate traffic, pedestrian, and cyclist information from the detectors and request right-of-way or inform motorists of non-motorized user in the crosswalk/pathway.

➢ Intersection Safety Warning and Collision Avoidance (VS13)

Equipped cars will use SPaT data in conjunction with the vehicles speed and acceleration profile, along with the signal timing and geometry information to determine if the vehicle can safely pass through the intersection. The controller will send a signal status to the RSU and the RSU will broadcast a TIM to the OBU alerting motorists.

4 How does I-4 FRAME work?
CV Applications

Phase I – Manual / Operator Assisted Response

Phase I requires RTMC operator to push a Traveler Information Message (TIM) to the RSU for broadcast to the OBU. The majority of CV applications on both the freeway and arterials will be accomplished through TIMs being broadcast with the applicable information.

SunGuide© is undergoing numerous enhancements to assist the operators in being able to quickly develop response plans and push TIMs accordingly.

Phase II – Semi-Automated/Automated Response

Phase II will semi-automate or automate the response to a majority of CV applications. For example, for the Queue Warning application, if congestion is detected and a back-of-queue is approaching, the RSU will receive the BSM data and automate the TIM message in response.

SunGuide© is undergoing numerous enhancements to help automate the response plans pending on the CV application.

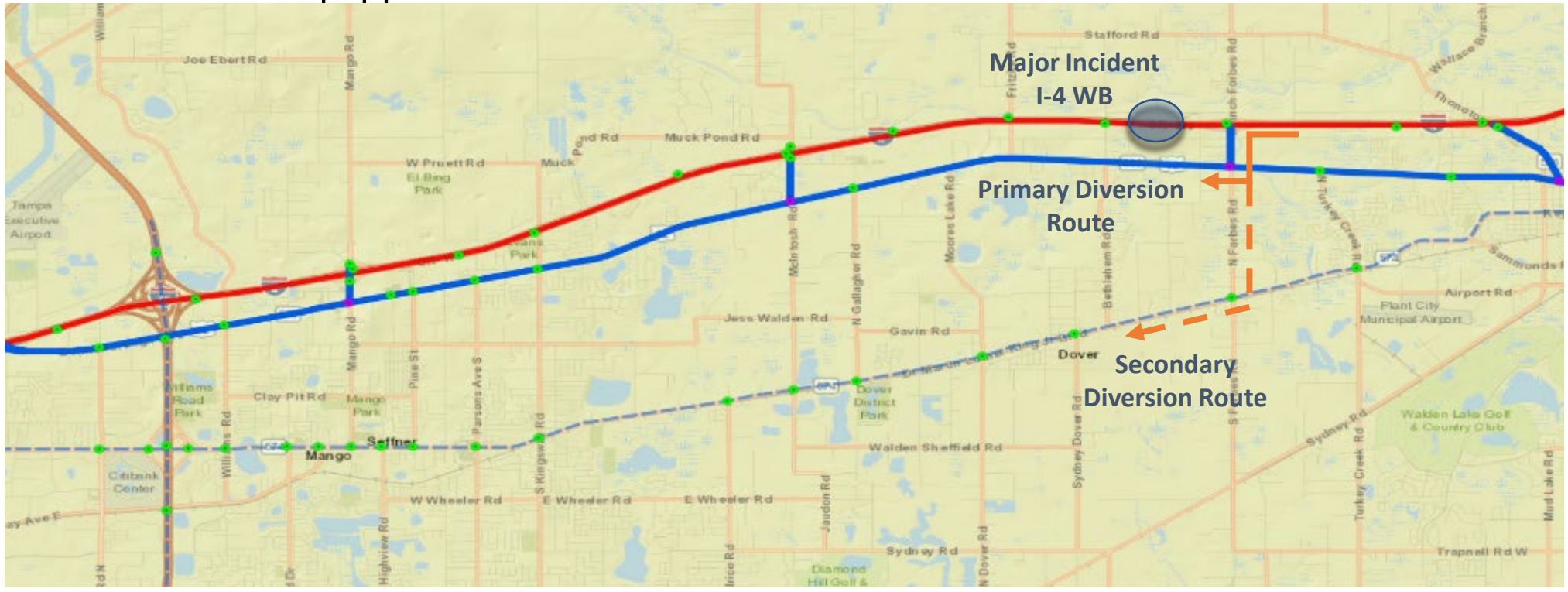
4

How does I-4 FRAME work?

Operational Scenario – Pre-Incident

Operational Steps

- Pre-determined incident response plans created with collaboration between Local Agencies and FDOT
- Travel times are being monitored along corridors via Bluetooth and CV data
- Procedures (SOPs/SOGs) agreed upon by Local Agencies and FDOT
- All intersections are monitored using traditional ITS technologies and RSUs receiving data from vehicles equipped with OBUs



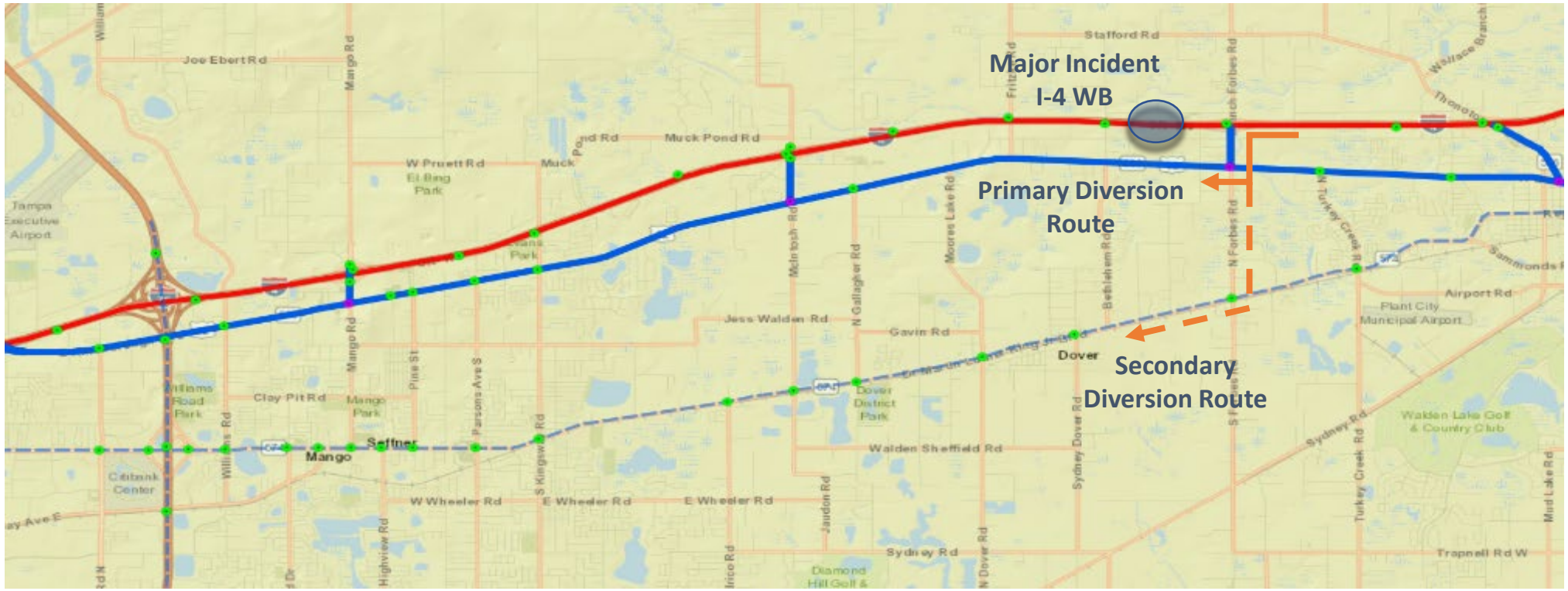
4

How does I-4 FRAME work?

Operational Scenario – During Incident

Operational Steps

- RTMC will notify Maintaining agency of incident
- FDOT and Local Agency agree to implement planned diversion route
- RTMC will create TIM Message and broadcast to OBUs from RSUs
- Westbound I-4 Freeway DMS will direct motorists to use US 92 via Branch Forbes Rd
- Blank out signs (BOS) at intersection of Branch Forbes Rd and US 92/Hillsborough Ave will guide motorists
- As primary diversion route saturates, BOS will direct traffic to use secondary diversion route along MLK Jr. Blvd.



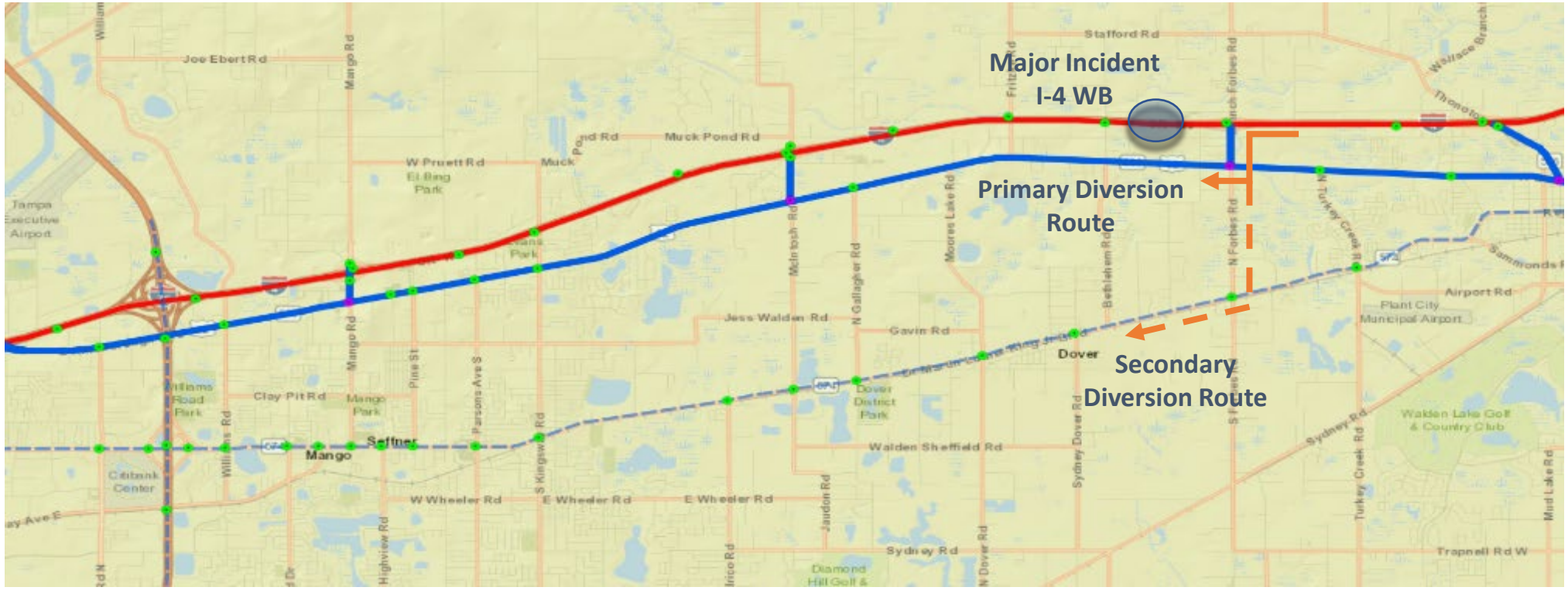
4

How does I-4 FRAME work?

Operational Scenario – Post Incident

Operational Steps

- Diversion broadcast ends once lanes are cleared
- Continued monitoring of traffic on arterials until timings can be returned to time of day
- Report of incident and response generated



5 When will the I-4 FRAME be built?

FPID	Project Name	Design Completion	Contractor Selection (Let)	Approx. Construction Cost
Construction Contract 1				
445362-2	I-4 FRAME (D7)	Fall 2021	Spring 2022	$10.5M
447012-1	SR 60 CAV	Fall 2021	Spring 2022	$1.5M
Construction Contract 2				
445362-3	I-4 FRAME (D1)	Spring 2022	Summer 2022	$10.5M
445362-4	I-4 FRAME (D5)	Spring 2022	Summer 2022	$4.1M
Construction Contract 3				
445362-5	I-4 FRAME (FTE)	Spring 2022	Summer 2022	$700K

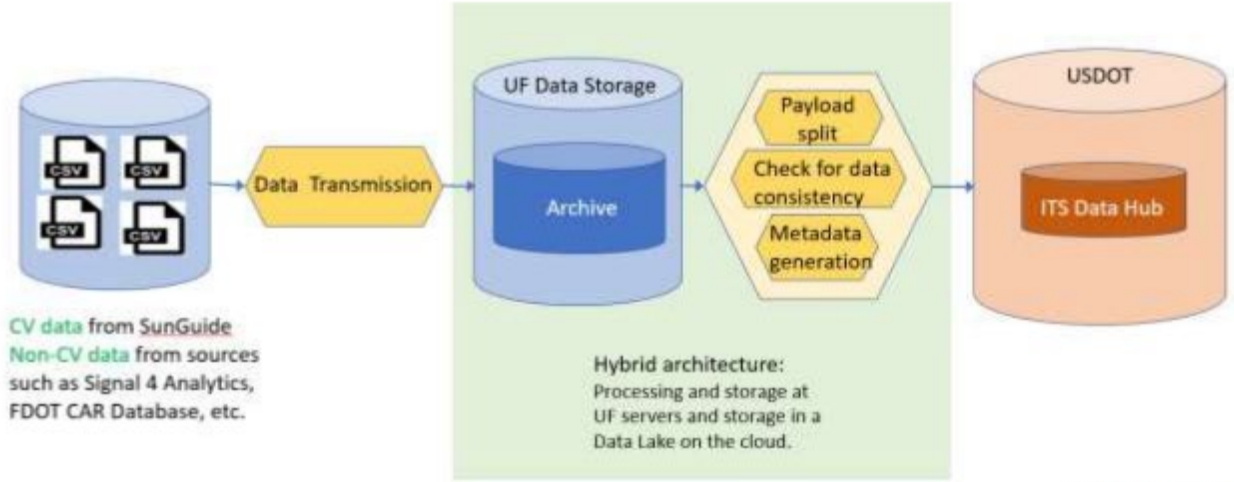
Preliminary Construction Schedule:

- D7 I-4 FRAME, SR 60 CAV– Summer of 2022 to Summer of 2024
- D1, D5, and FTE I-4 FRAME – Fall of 2022 to Early 2025

Additional I-4 FRAME ATCMTD Tasks
Data Management Plan (DMP)

DMP Describes the data to be collected for evaluation, the processes to manage, store data reliably, and share relevant evaluation data with the USDOT and relevant stakeholders

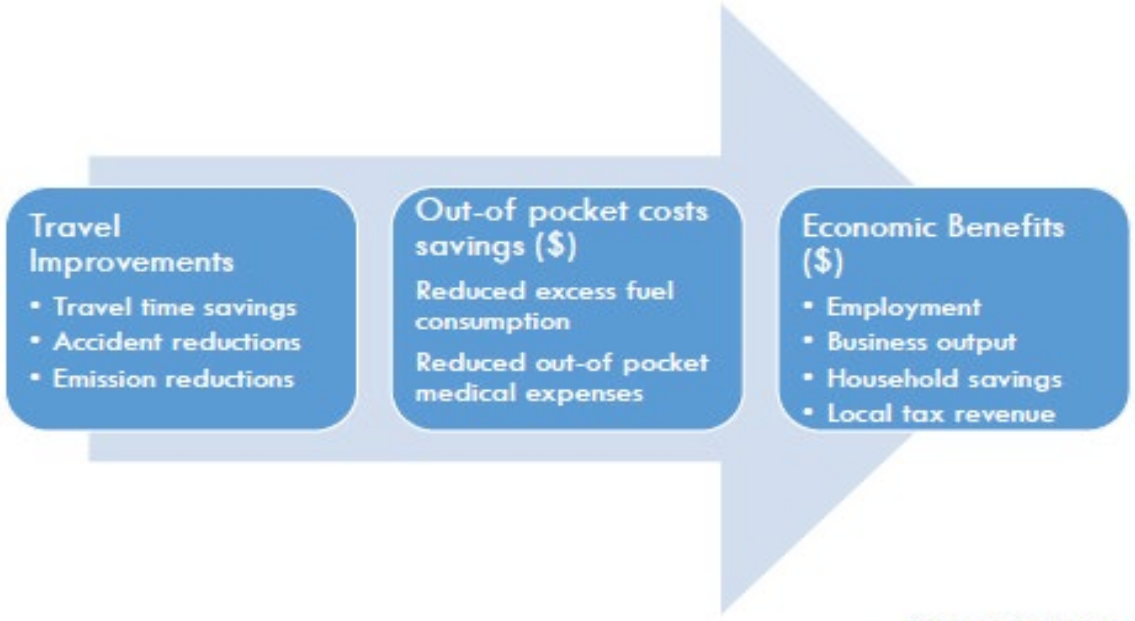
- **Data Storage –**
  - Data will be stored on a UF Server for a 24-hour period and then uploaded to the Data Lake in the cloud
- **Data Security –**
  - UF Server - all data will be encrypted
  - Cloud data - data protection service provided by cloud provider
- **Backup and Recovery –**
  - UF will utilize backup and recovery options provided by cloud provider
  - Data lake will archive cold data, older than a year, and for long term backup



Source: UF, 2021

Additional I-4 FRAME ATCMTD Tasks
Project Evaluation Plan (PEP)

- Describes project goals, evaluation methodology and design, performance measures, data collection procedures and risks
- Evaluation Goals
  - Improve Safety
  - Improve Mobility
  - Reduce Costs and Increase Economic Benefits
  - Share Institutional Benefits



Source: CUTR 2019

Additional I-4 FRAME ATCMTD Tasks
Research Projects

The following Universities are assisting with the Before and After Study Evaluations:

- University of South Florida (USF) CUTR
- University of Central Florida (UCF)
- University of Florida (UF)
- Florida Polytechnic University

Thank You!

Contact Information:

Ronald A. Chin, PE
District Seven Traffic Operations Engineer
ronald.chin@dot.state.fl.us
813.975.6253

Speaker

Mr. Mike Brown, PMP
Institute Engineer, Southwest Research Institute

FDOT's V2X Data Exchange Platform: Ideation, Initiation, and Implementation

State of Florida Department of Transportation
Vehicle-to-Everything (V2X) Data Exchange Platform (DOT-ITN-20-9104-SJ)
Agreement/Contract No: BEB93

Vehicle-to-Everything (V2X) Data Exchange Platform

Florida Automated Vehicle Summit

November 30th, 2021

amazon aws

FIU FLORIDA INTERNATIONAL UNIVERSITY

FORD MOBILITY

Google

iteris®

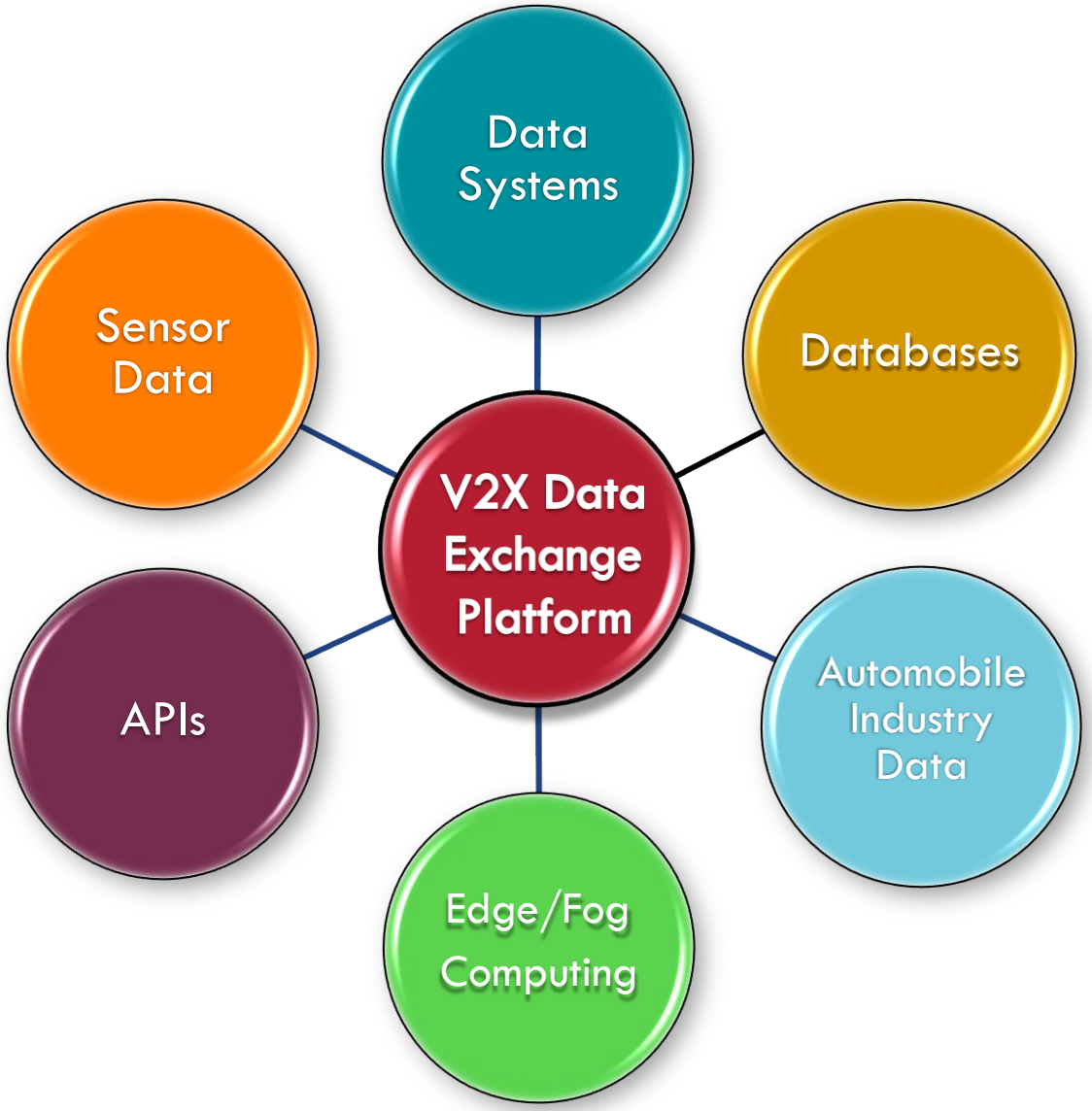
kodiak

SwRI® SOUTHWEST RESEARCH INSTITUTE

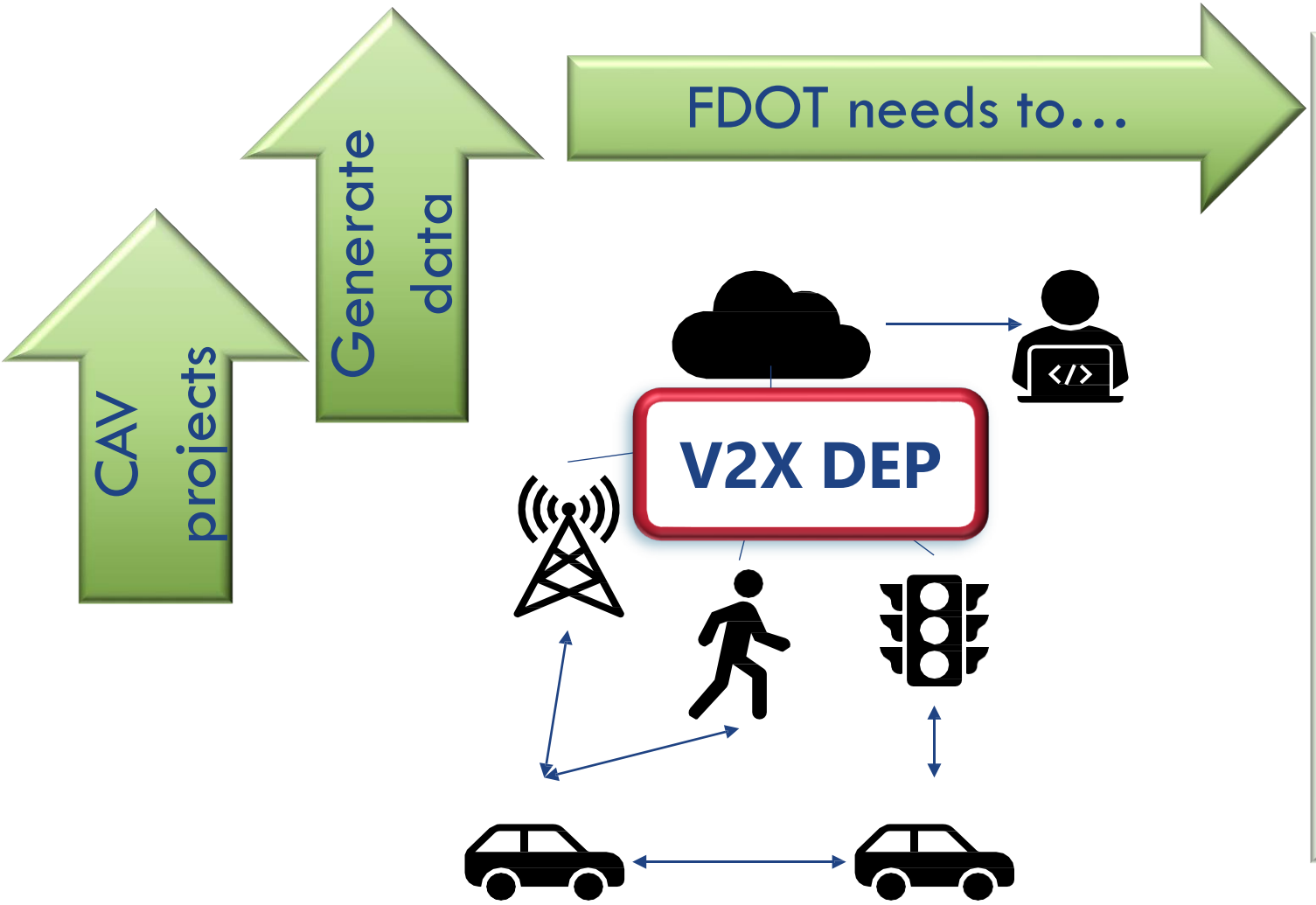
V2X Data Exchange Platform Concept

- V2X data platform:
  - Ingests data from **CAV devices** (roadside units (RSUs) and on-board units (OBUs))
  - Ingests data from **ITS devices**
  - Ingests data from **third parties**
  - Potentially interacts with **SunGuide®**
  - Allows data to be shared between computer programs, data systems, and users

- Ultimate solution for data generated in all CAV projects in Florida



Purpose and Need of V2X DEP

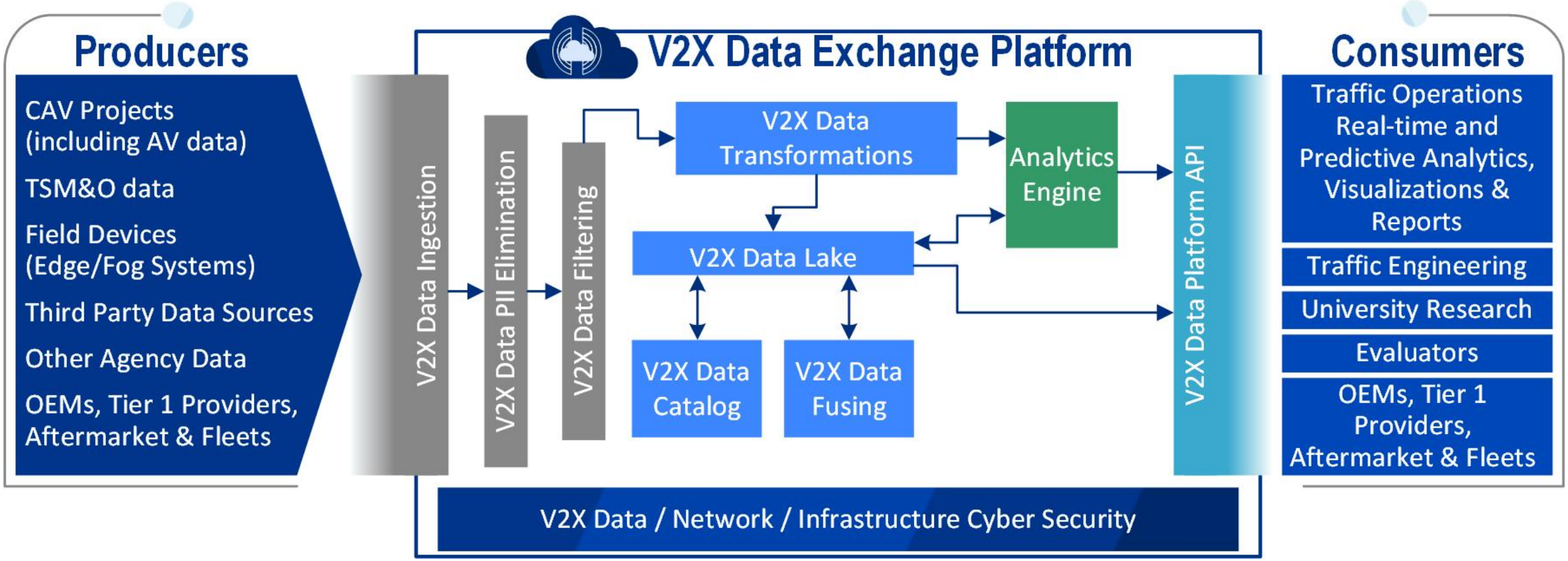


- Collect, manage, and store CAV data
- Coordinate with and integrate additional data sources and systems
- Normalize, filter, aggregate, and disseminate data
- Send and receive data from automobile OEMs (reduce OBU purchasing)
- Develop real-time and predictive analytics
- Leverage existing infrastructure
- Provide visualization

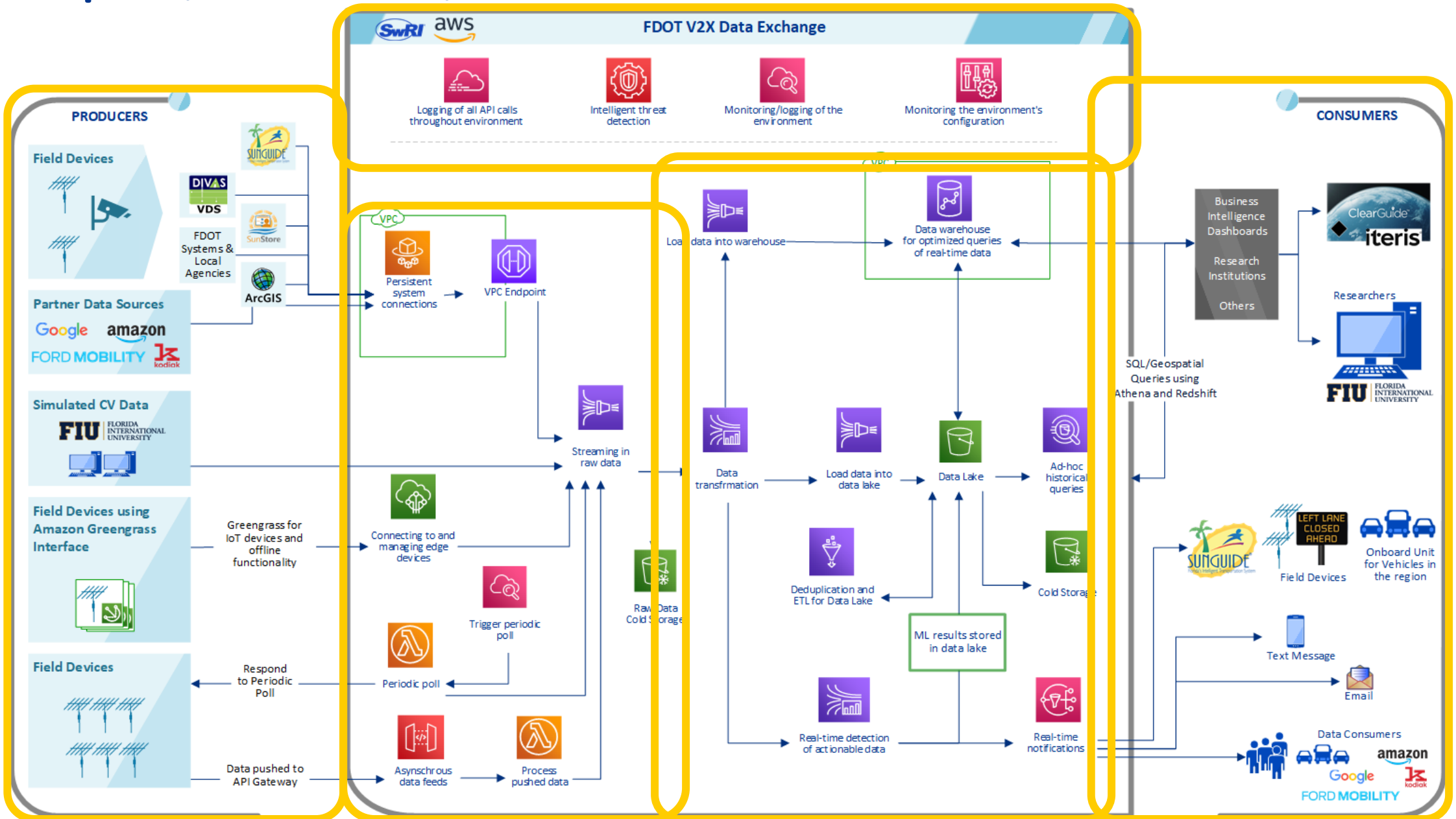
Platform Users

- Cloud-Based Strategy
- Device Drivers and APIs
- Real-time and Predictive Analytics
- Edge Computing
- Requirements and Specifications
- Open-Source and Open-Architecture Tools

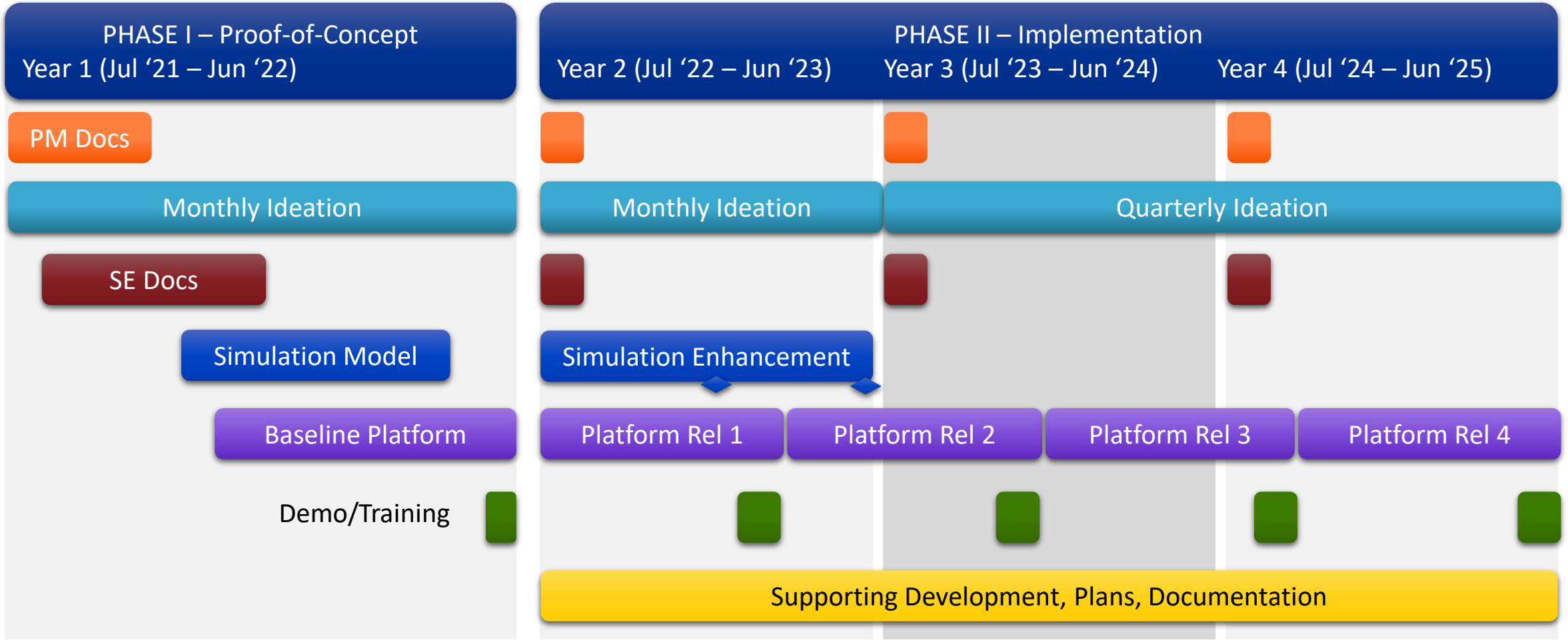
Platform Architecture



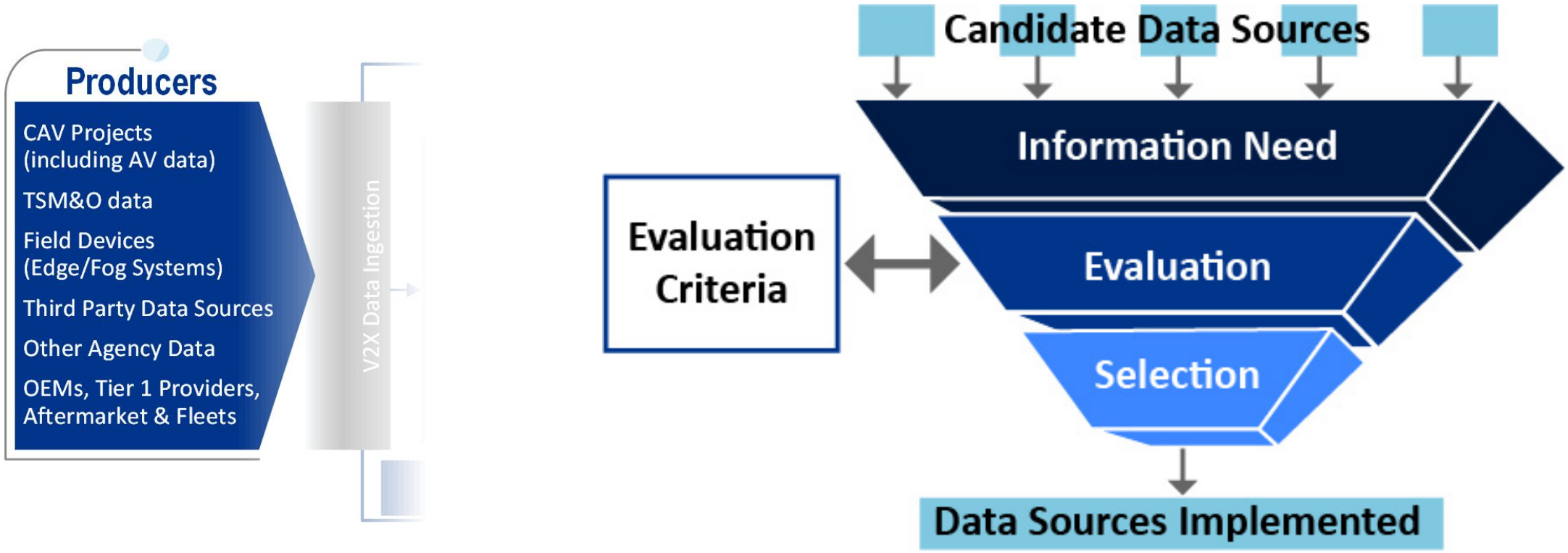
Open, Modular, Scalable V2X Architecture Solution



Project Schedule



Prioritizing Data Sources



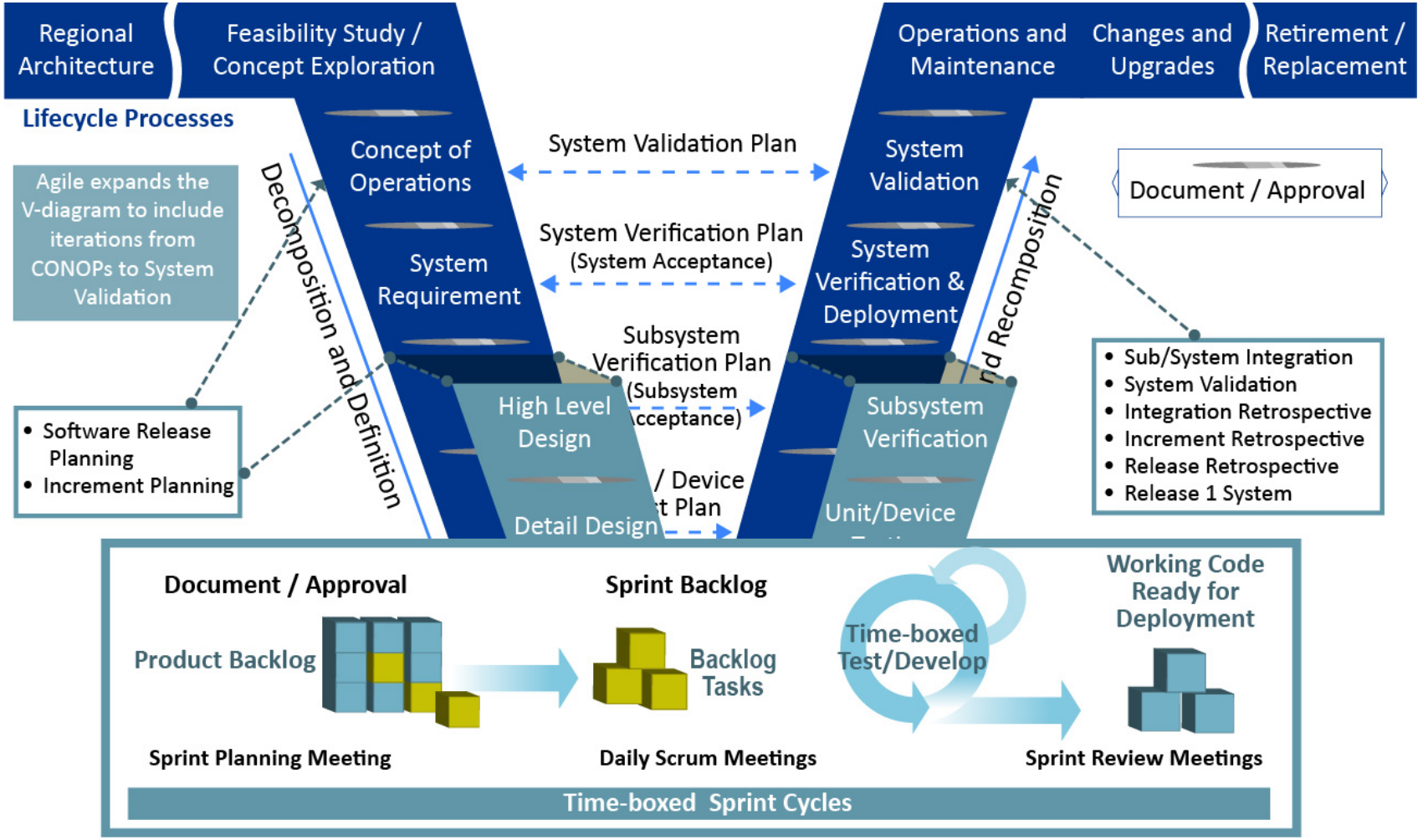
Prioritizing Data Sources

Release	Data Elements
POC Phase 1 Release 1 **12 months**	GIS, Ford, SunGuide (event data – LC, DMS), ClearGuide traffic, ClearGuide Waze
Phase 2 Release I **21 months**	CAV/Map/SPaT, SunGuide (event data - Crash, RWIS, TSS), NWS
Phase 2 Release 2 **30 months**	SunGuide (event data – remaining scope), External (DMS, RWIS, TSS, event data – Crash & LC), CAD, RSU (RSM, TIM)
Phase 2 Release 3 **39 months**	ATSPM, Fleet (AWS, Kodiak), TSM&O, raw traffic, Work Zone Data Exchange
Phase 2 Release 4 **48 months**	DIVAS, External (event data – remaining scope), Waze (direct/raw)

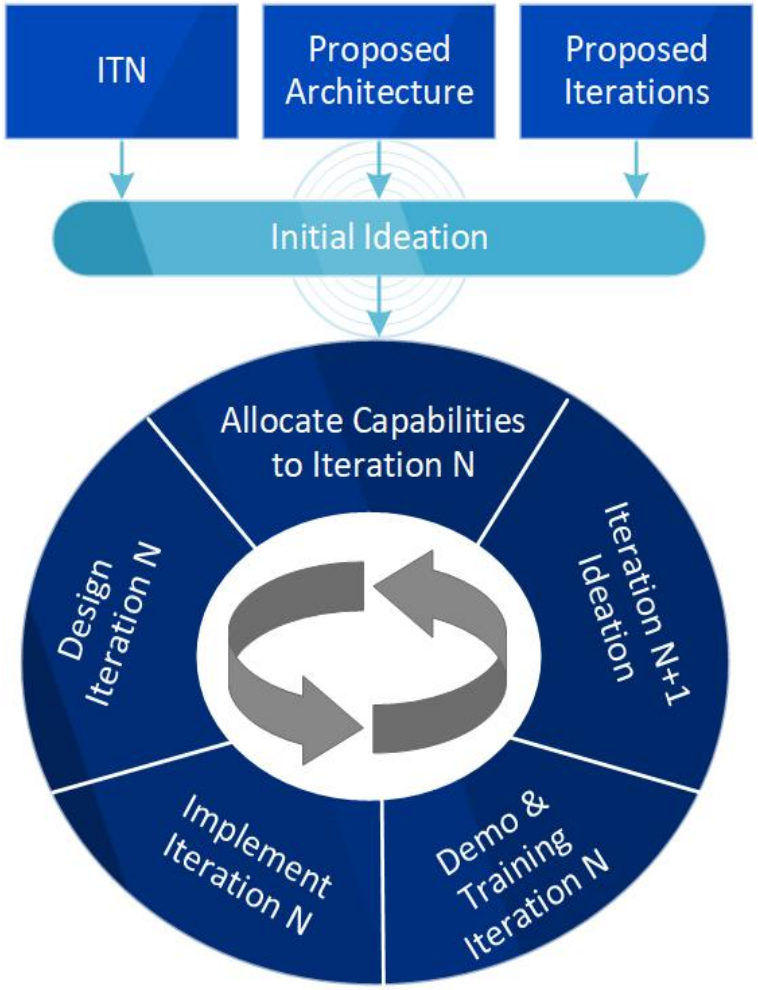
Evolving Architectural Elements

Release	Architectural Elements
POC Phase 1 Release 1 **12 months**	Site-to-site VPN, data-agnostic ingestion pipeline, data lake infrastructure, real-time analytics infrastructure, real-time notification infrastructure, ClearGuide integration
Phase 2 Release I **21 months**	Enhance following toward SLA metrics: data-agnostic ingestion pipeline, data lake, real-time analytics, real-time notification
Phase 2 Release 2 **30 months**	Site-to-site VPN for non-FDOT partner agencies, enhance following toward SLA metrics: data-agnostic ingestion pipeline, data lake, real-time analytics, real-time notification
Phase 2 Release 3 **39 months**	Enhance following toward SLA metrics: data-agnostic ingestion pipeline, data lake, real-time analytics, real-time notification
Phase 2 Release 4 **48 months**	Enhance following toward SLA metrics: data-agnostic ingestion pipeline, data lake, real-time analytics, real-time notification

Systems Engineering Process Enhanced for Agile



Ideation Strategy



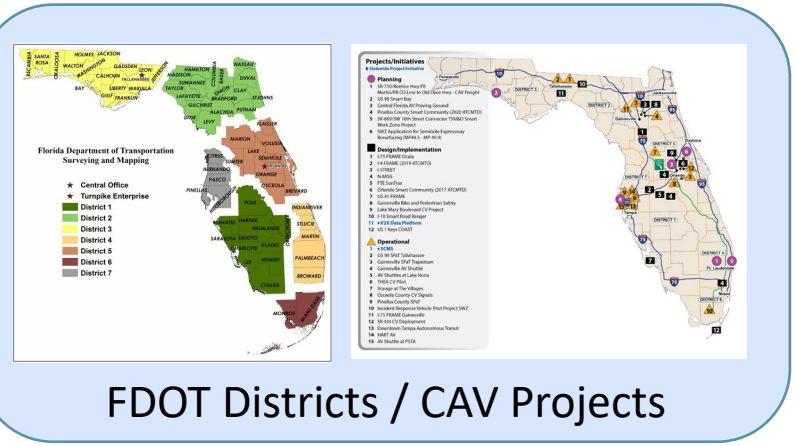
- Platform Users & Use Cases
- FDOT Systems & CAV Projects
- Analytics & Visualization
- Networking & Cybersecurity
- **Industry & Platform User Engagement**
- Phase 1 Delivery Prep Topics

Engagement with FDOT Districts / CAV Projects

Other Data Sources

What information would benefit the district?

V2X Platform



FDOT Districts / CAV Projects

What data could the platform ingest from the district?

Engagement with Industry

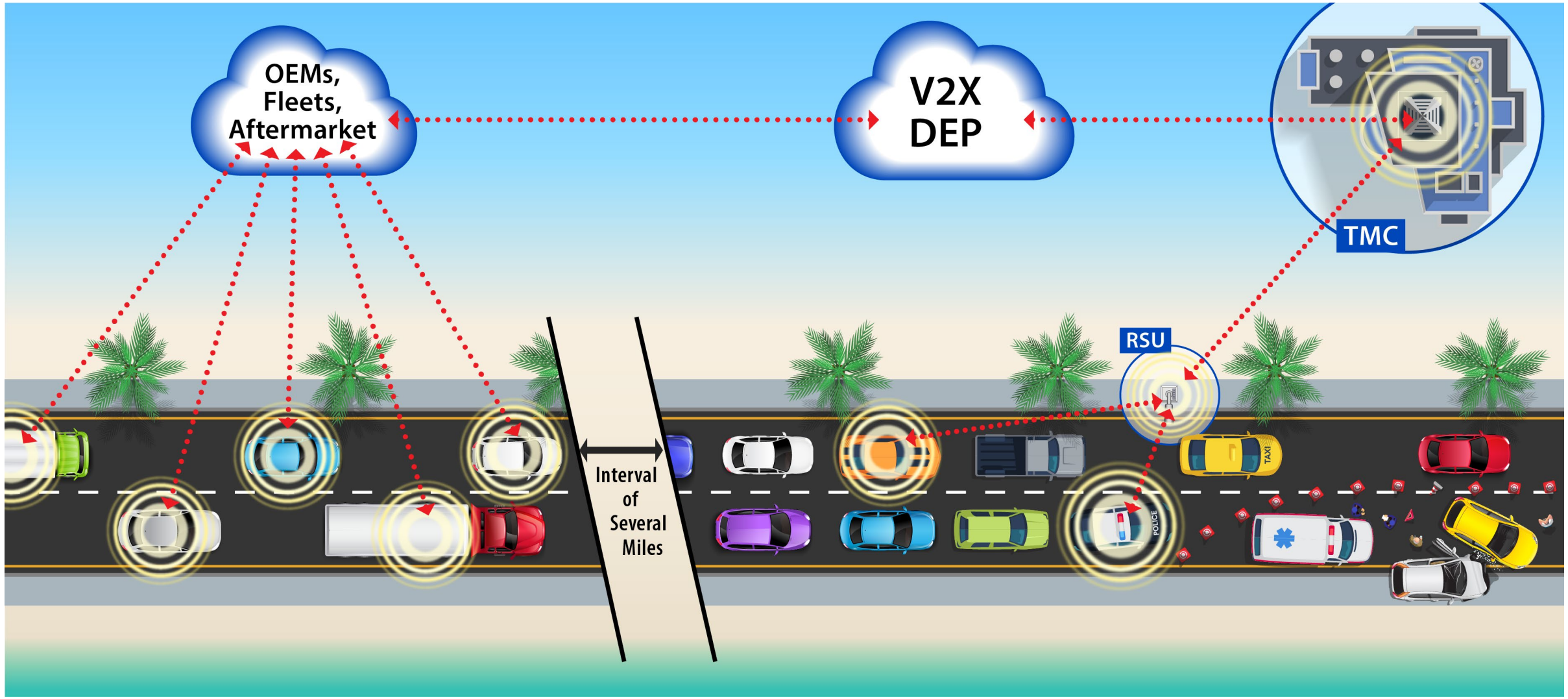
Deliver information to vehicles to improve safety, mobility and efficiency

Provide data to FDOT to improve operations and planning

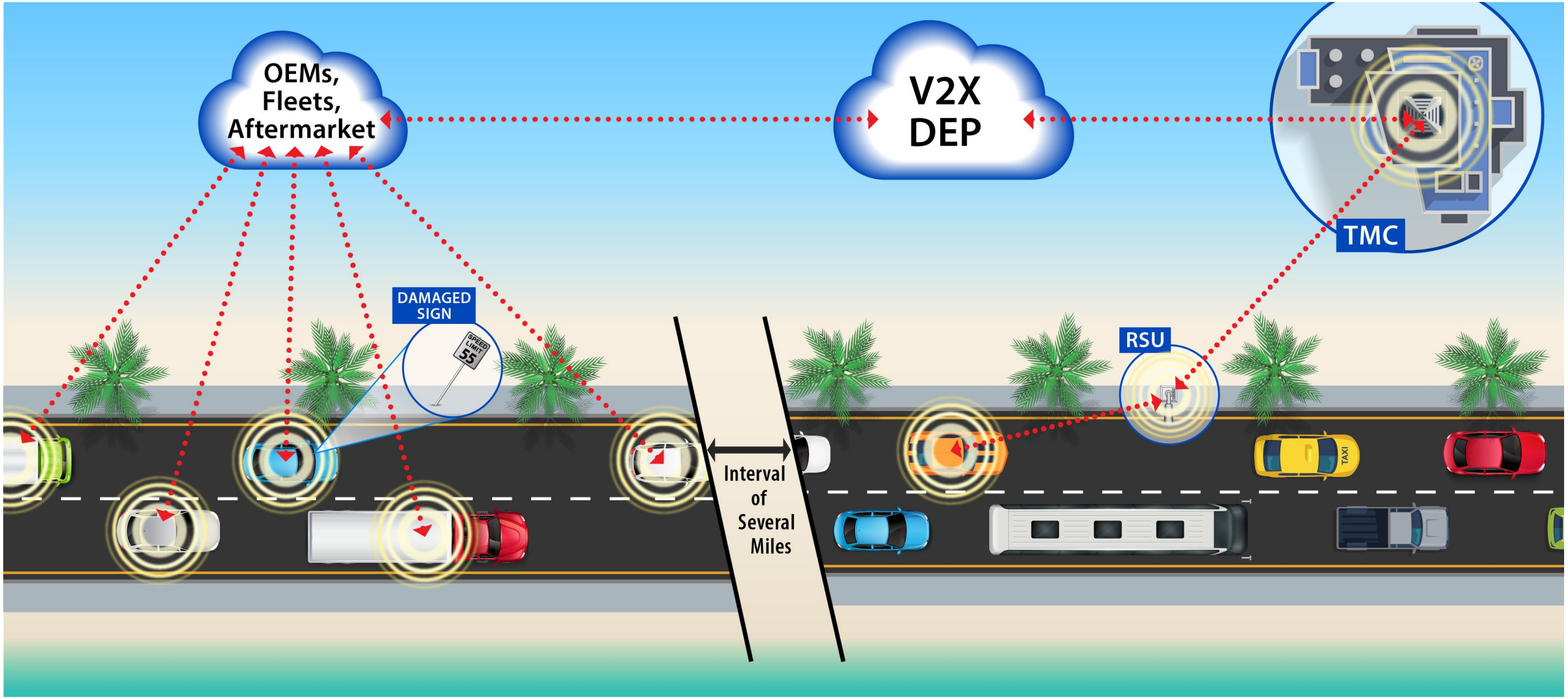
- Team includes representative set of key industry players
- Optimized for initial ideation, design, and implementation

- Platform will be open to all
- FAV community:
  - **What information would benefit you?**
  - **What data could you provide?**

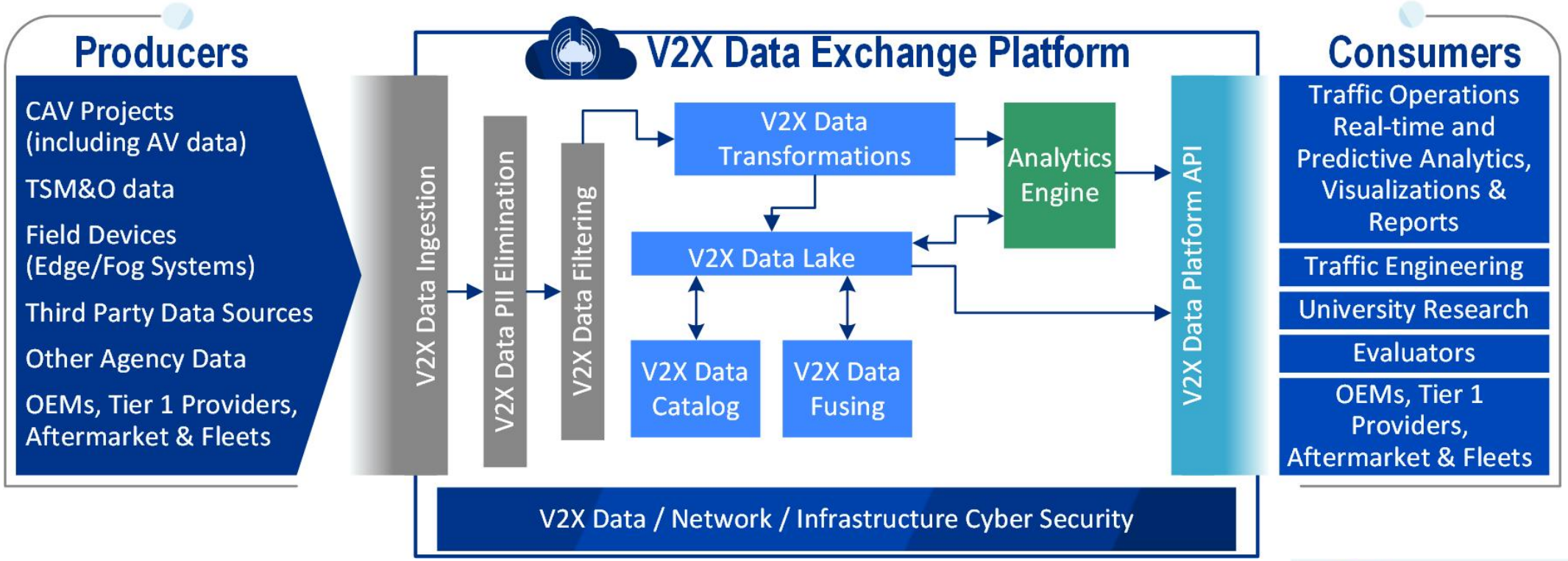
Example Use Cases – Traffic Hazards



Example Use Cases – Roadway Characteristics



Questions?



Contact: Mike Brown, SwRI – mabrown@swri.org

Speaker

Mr. Ryan Westrom, P.E.
Head of Mobility Engagement - East Coast, Ford Smart Mobility

Ford’s AV and CV Activities in Florida

An Overview of Ford's C-V2X Activities

FAV Summit – November 30, 2021

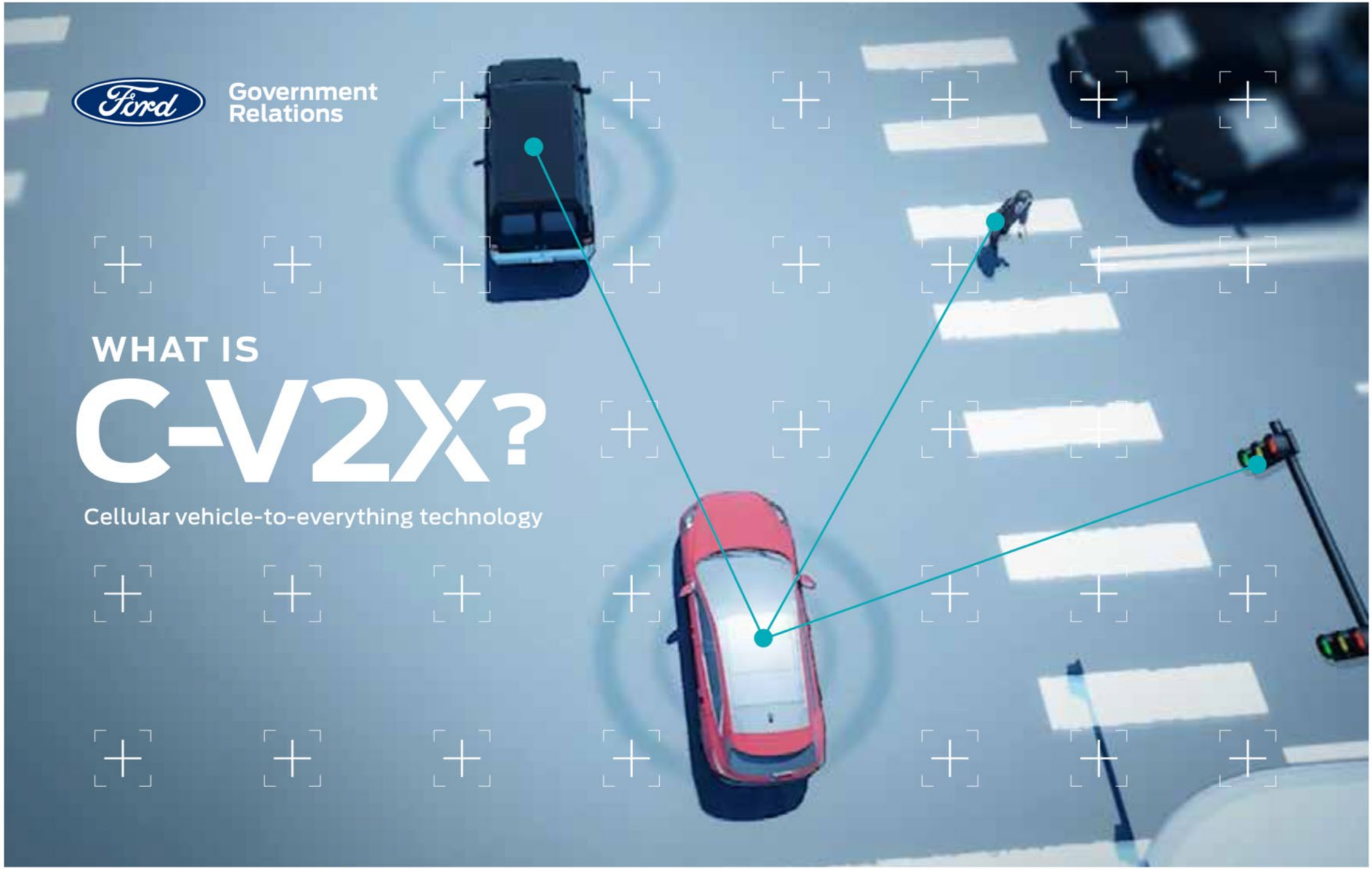
Agenda

- What is C-V2X?
  - How does C-V2X work?
  - Announced Deployments
  - C-V2X U.S. Policy Milestones
  - FCC 5.9 GHz Update
  - Relevant Standards
- Planning for the Future

Government Relations

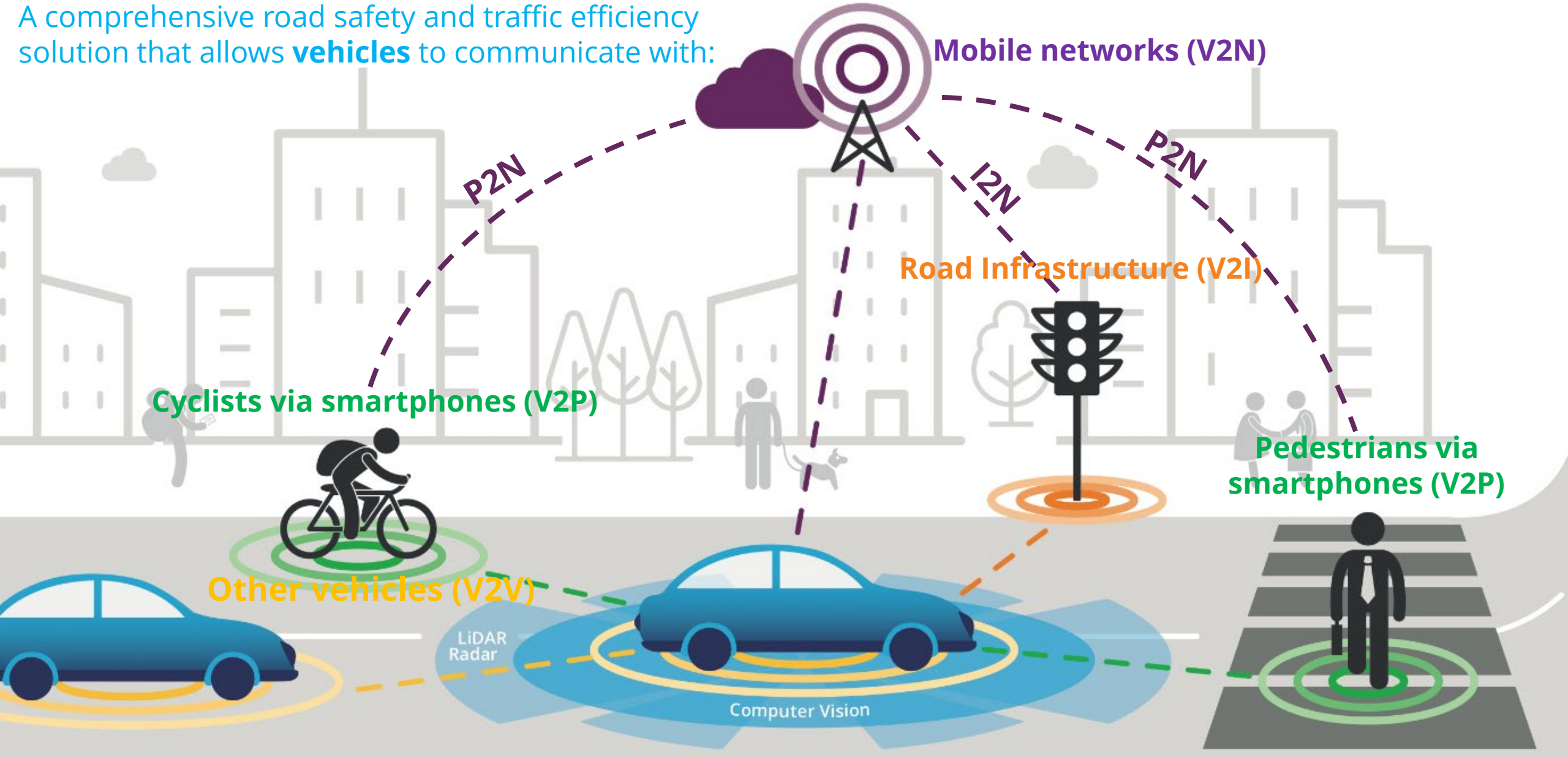
WHAT IS C-V2X?

Cellular vehicle-to-everything technology

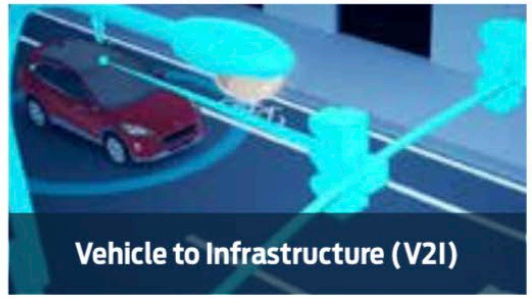


What is C-V2X (Cellular-Vehicle to Everything)?

A comprehensive road safety and traffic efficiency solution that allows **vehicles** to communicate with:



Vehicle to Vehicle (V2V)



Vehicle to Infrastructure (V2I)

Vehicle to Network (V2N)

Vehicle to Pedestrian (V2P)

In the next few years

Ford will begin deploying C-V2X in U.S. vehicles*

** Ford will begin deploying C-V2X in its U.S. vehicles, provided a supportive regulatory framework is in place.*

Cellular vehicle-to-everything technology (C-V2X) lets vehicles share data directly, in real time, so vehicles are instantly aware of safety, road, and traffic conditions.

This technology uses both mobile network, and direct communications, to connect vehicles to each other, to the cloud, to infrastructure, and to pedestrians, making their environments safer.

HOW DOES C-V2X WORK?

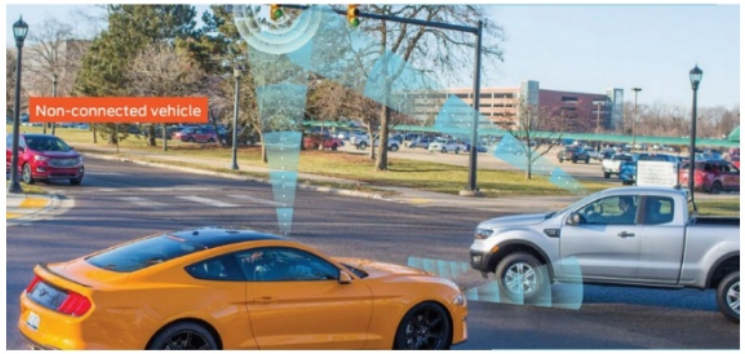
C-V2X communications work by using a specific band of wireless spectrum (the 5.9 GHz band) licensed by the Federal Communications Commission. The FCC manages private-sector spectrum usage and defines which services can operate within specific radio frequencies. And each use can only operate within the specific spectrum they're allotted.

5.9 GHZ BAND

The 5.9 GHz band is the perfect space for C-V2X, which can carry connected vehicle data far, fast and with a solid signal because it can operate in a section of the spectrum that is dedicated to auto safety, and free from harmful WiFi interference.

Announced U.S. C-V2X and 5G Deployments…

Ford intends to start deploying C-V2X



Credit: Ford

Audi Newsroom

Press releases | Models | Gallery

Audi of America, Virginia DOT and Qualcomm Announce Initial C-V2X Deployment in Virginia

Audi, Applied Information and Temple launch C-V2X school safety development program in Georgia

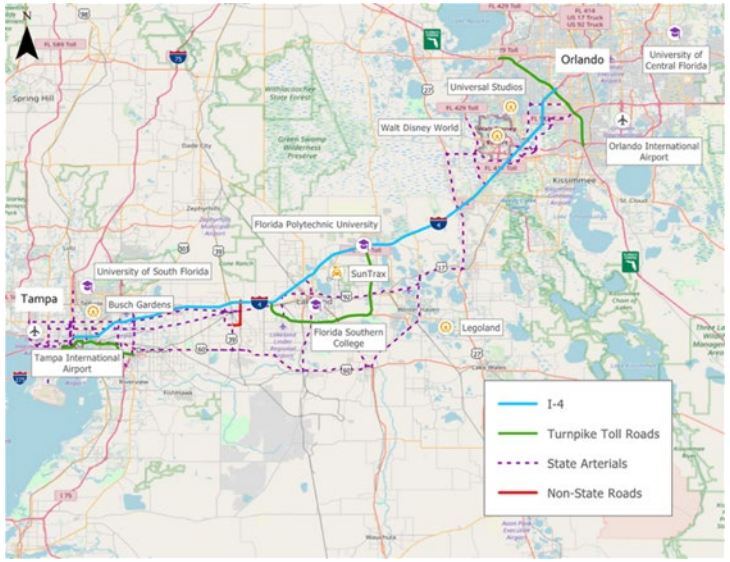
BMW and Samsung to offer 5G in the iNEXT as soon as 2021

…Ford in Florida

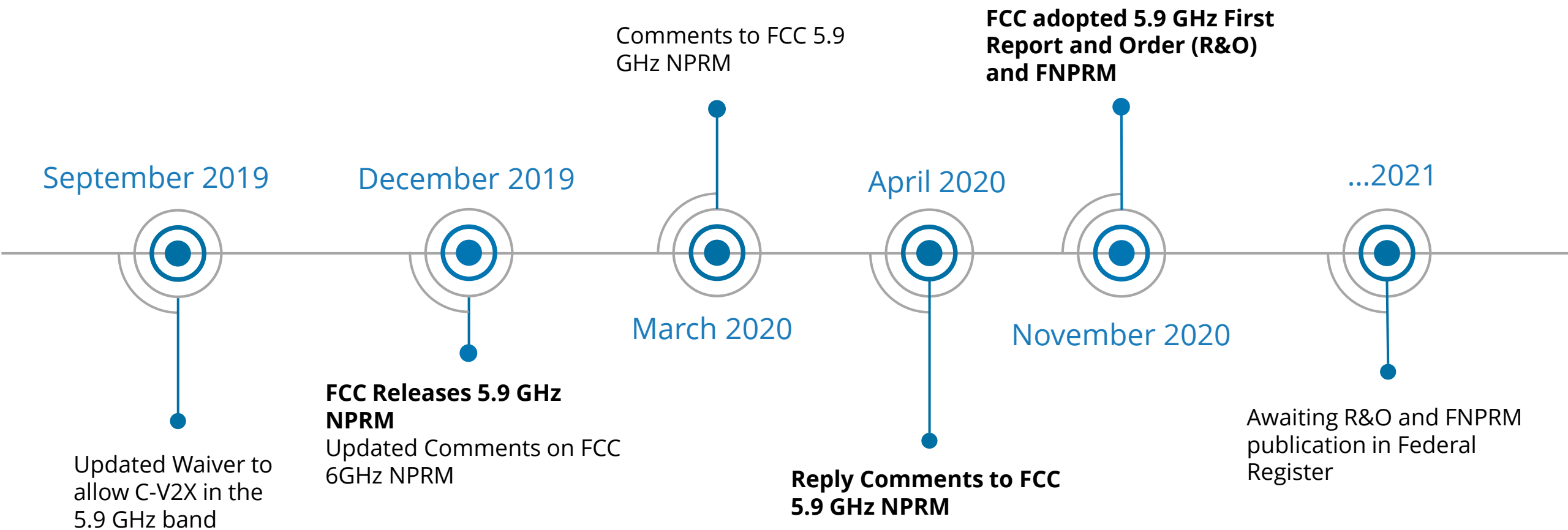
FDOT Vehicle-to-Everything (V2X) Data Platform

V2X·DEP

I-4 FRAME



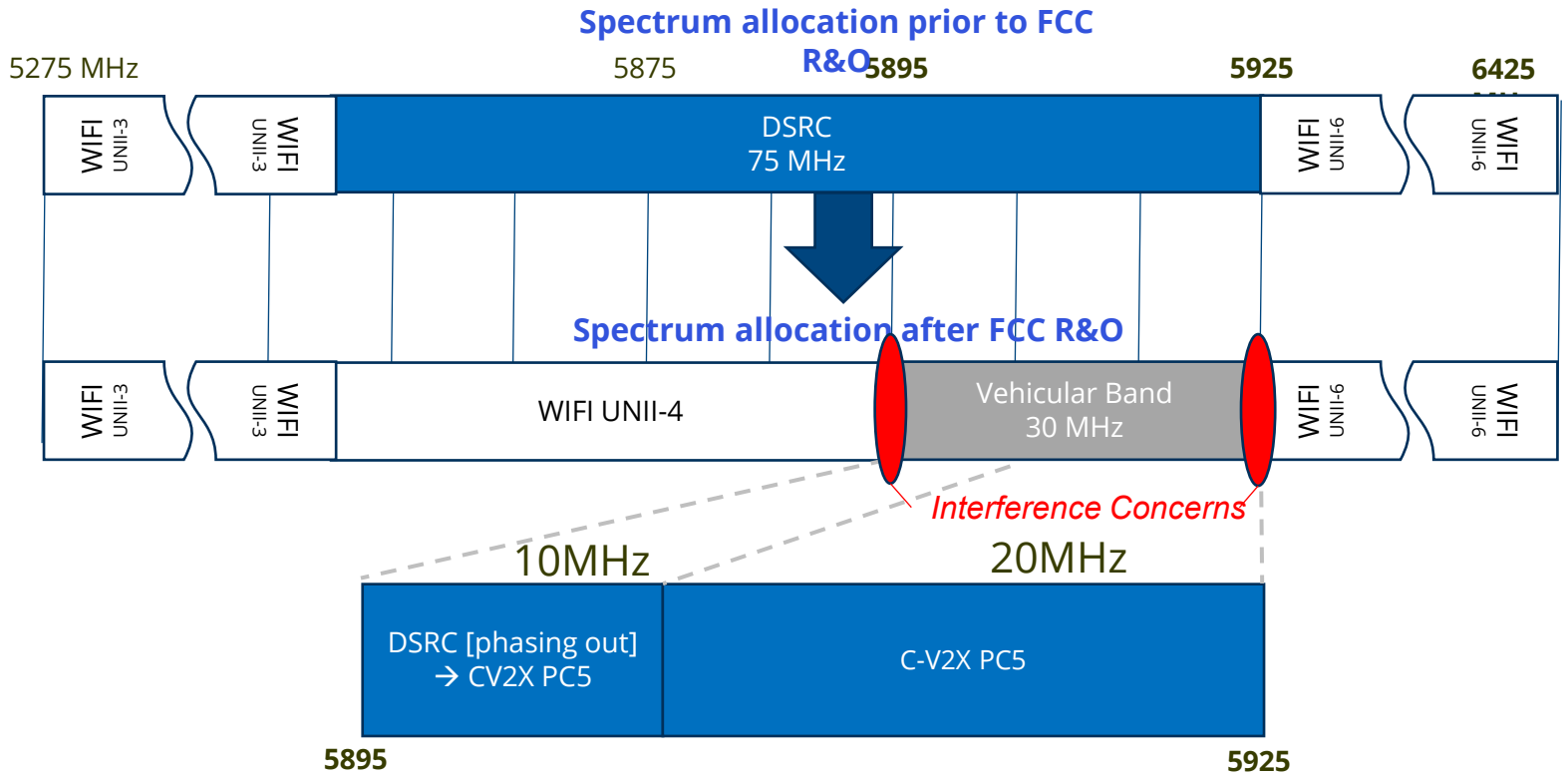
C-V2X U.S. Policy Milestones



US 5.9 GHz Spectrum Update

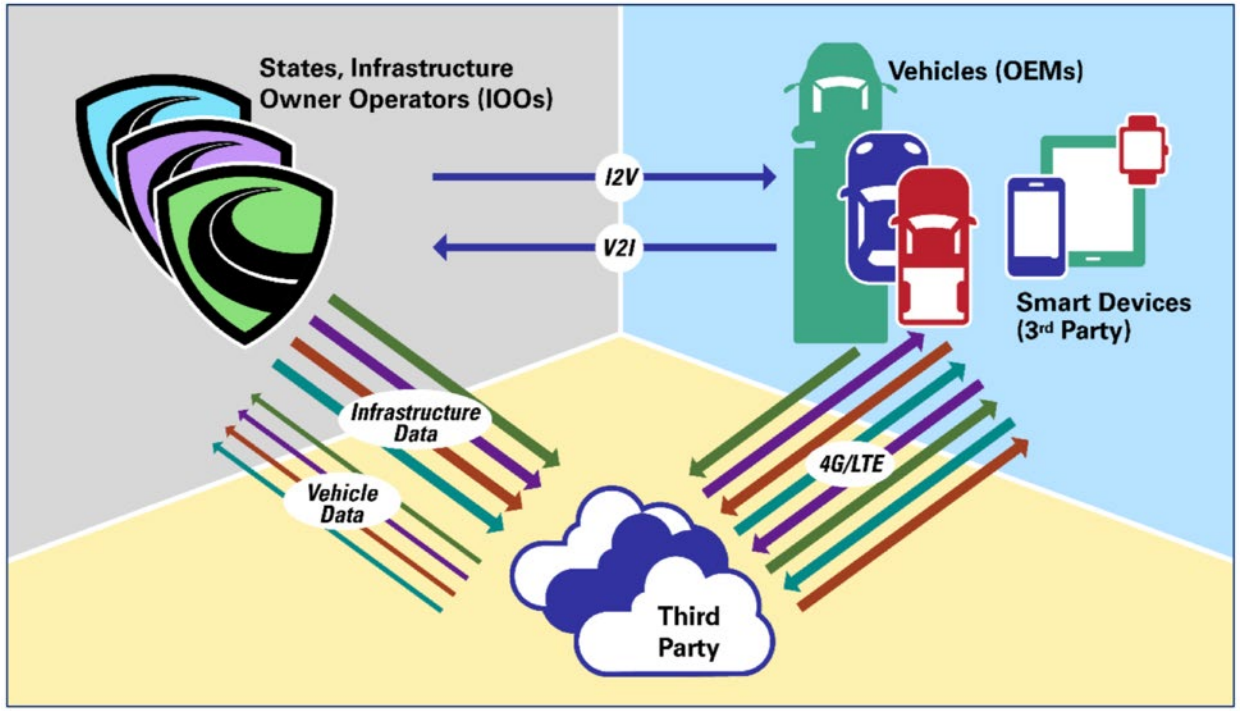
The US FCC 5.9 GHz ruling points to **C-V2X as technology of choice:**

- Allows C-V2X in upper 30 MHz for RSUs and OBUs after expedited waiver process
- DSRC will move to upper 30 MHz until end of phasing out period (2 years)
- FCC puts spotlight on OEMs to bring V2X to the finish line



C-V2X Relevant Standards

A key ecosystem advancement helping bring **C-V2X technology** to scale will be maturation of governing standards and specifications allowing shared communication protocols. Some relevant standards include:



source: SWRI

Governing Body	Standard	Applicable Technology	Date
3GPP	C-V2X	Support for V2V services based on LTE sidelink (RP-161919)	2016
ASTM	E2213-03	Standard Specification for Comms Exchange Between Roadside and Vehicle	2010
ETSI	EN 302 663	ITS access layer technology (ITS-G5)	2012
IEEE	1609	Wireless Access in Vehicular Environments (WAVE)	2019
IEEE	802.11p	Wireless Access in Vehicular Environments (WAVE)	2010
ISO	TC204	Intelligent Transport Systems	varies
ITE	I2V CI Data Framework	Connected Intersection SPaT Comms	WIP
ITE	TMDD 3.1	ITS Center-to-Center Comms	2020
NTCIP	1202	Object Definitions for Actuated Traffic Signal Controller (ASC) Units	2005
SAE	J2735	V2X Communications Message Set Dictionary	2020
SAE	J2945/1	On-Board System Requirements for V2V Safety Comms	2020
SAE	J2945/4	Road Safety Applications	WIP
SAE	J3161/1 *	On-Board System Requirements for LTE V2X V2V Safety Comms	WIP
SAE	J3217 *	V2X-Based Fee Collection	WIP
US DOT	WZDx	Work Zone Data Exchange v. 3.1	WIP

** Denotes Ford involvement in standard development (also: SAE J3161, J3161/1A, J3163, J2945/A, J2945/B,*

“Billions of dollars already are being spent

as the cellular industry builds 5G networks, so we think the timing is perfect to give our vehicles some of the natural skills we use every day to get around.”

Ford Executive Director, Connected Vehicle and Services

WHY DOES FORD CARE?

Ford is committed to advancing in-car technologies to make vehicles safer and smarter as part of the next generation of connected mobility. Soon, Ford will be deploying C-V2X in its U.S. vehicles, provided a supportive regulatory framework is in place.

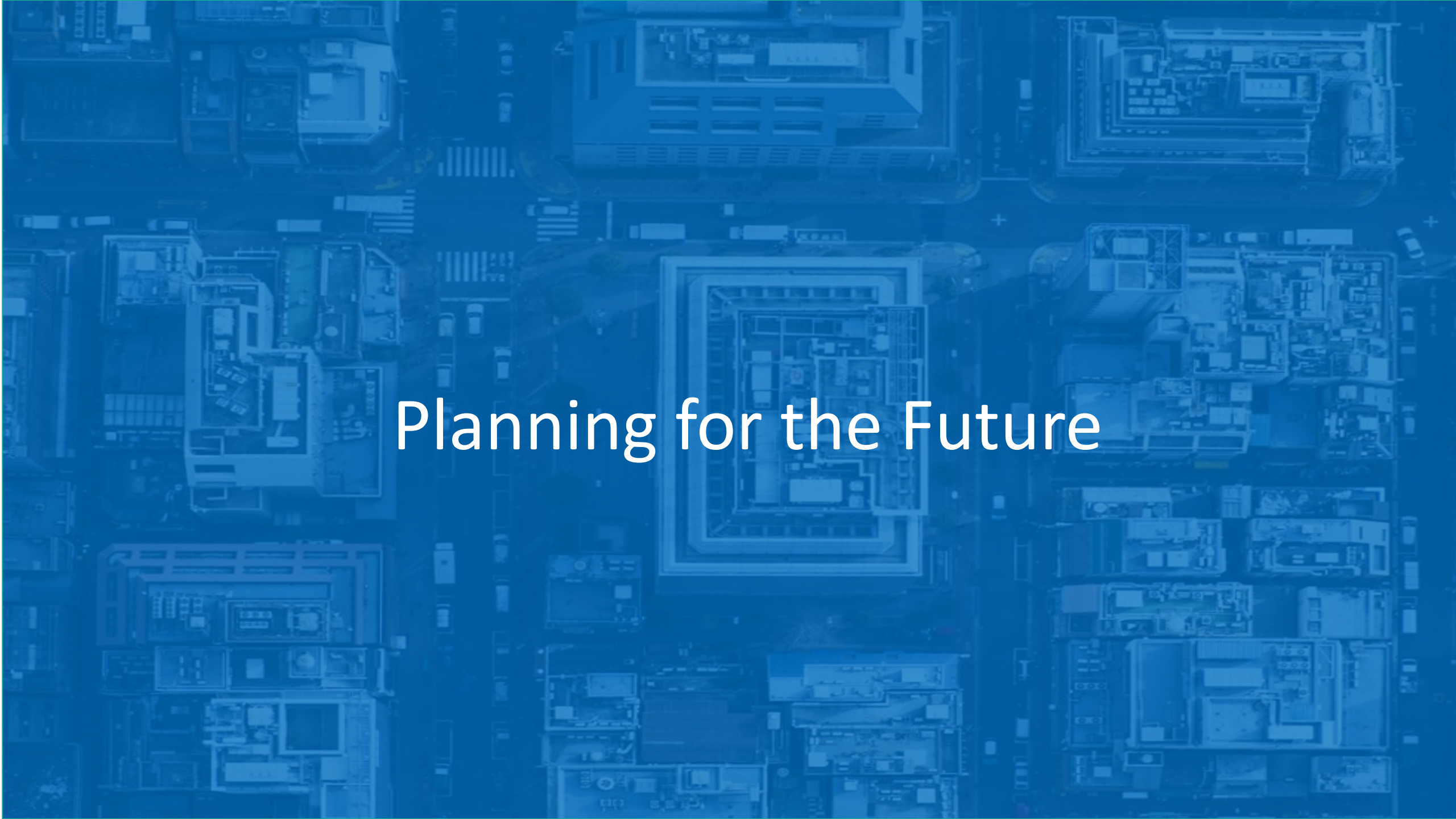
WHAT DOES FORD WANT?

C-V2X, operating in the intelligent transportation safety band, is the future of automotive technology. This future requires a supportive regulatory framework in order to realize the full potential of C-V2X technology.

Ford Government Relations

We need to modernize US infrastructure by making it smart and connected

- Provide guidance and funding to State and local DOT's to encourage deployment
- Ensure funding flexibility with federal programs
- Increase smart infrastructure to encourage more OEM deployments as well



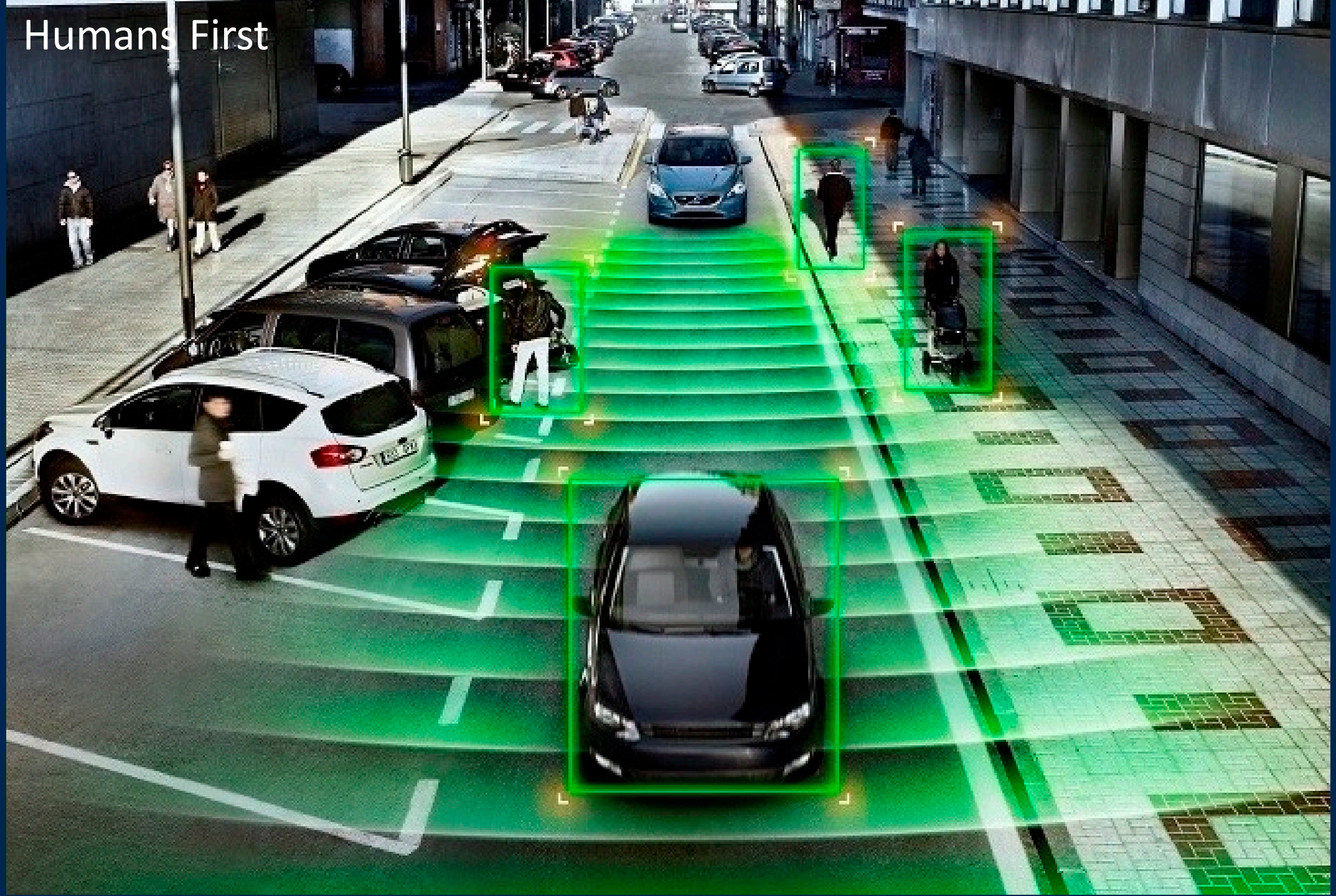
Planning for the Future


M O B I L
I T Y
T S ...
FORD
SURF CENTER
HOT ROD PAINT

HUMAN

PHOTO: Seattle Department of Transportation

observe interactions, collect data


Humans First

Today For Tomorrow

PHOTO: Seattle Department of Transportation

Questions?

Ryan Westrom
Head of Mobility Engagement—East Coast
rwestrom@ford.com

Appendix

Vehicle Connectivity

- **The Industry is Committed to Connectivity**
  - Strong proponent of ITS
  - We need clear spectrum to launch
- **FCC's 5.9 R&O**
  - Would have preferred retention of full 75 MHz for ITS
  - Pleased with endorsement and allocation for C-V2X
  - Interference concerns
  - The need for additional spectrum for future use cases

Global Outlook on Tests, Trials and Demonstrations involving Cellular-V2X and/or 5G Technology

North America

USDOT testing
(Aberdeen, USA)

SANDAG Trial
(San Diego, USA)

V2V C-V2X radio performance tests
(Michigan, USA)

CDOT traffic management trial and early deployment
(Colorado, USA)

Ford-Qualcomm V2X Technology Benchmark Testing
(Ann Arbor/San Diego, USA)

Audi, Ford, Ducate, Qualcomm Joint C-V2X Intersection Demonstration
(CES2019, Las Vegas, USA)

Europe

RACC Track (MWC2017, Barcelona, Spain)

NordicWay Project 1 & 2 (Finland, Norway, Sweden and Denmark)

ConVex (A9, Germany)

Mobilfunk (A9, Germany)

Deutsche Telekom Trials (A9, Germany)

Car2X (A9, Germany)

5G-CM (A9, Germany)

MEC Pilot Project (A9, Germany)

ICT4CART Project (Austria, Germany and Italy)

CONCORDA (Germany, Spain, France, Belgium, Netherlands)

Providentia (A9, Germany)

SAFARI (Berlin, Germany)

CAR2MEC (A9, Germany)

5G CroCo, 5G Carmen, 5G Mobix

Asia-Pacific

C-V2X Performance Test
(Shanghai International Automobile City, China)

Car2X (Wuzhen, China)

ICV Pilot Projects
(Various Cities, China)

Wuxi City-Wide LTE-V2X Project (Wuxi, China)

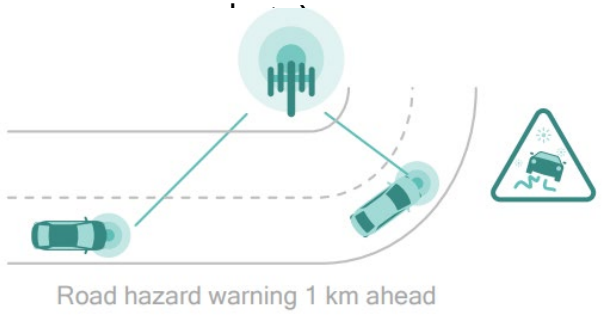
Triple Level LTE-V@X IoT and Applications Demonstration
(Shanghai Automotive Expo Park, China)

5G and cellular communication showcase trials
(Korea)

C-V2X evolution roadmap towards 5G

Traffic Efficiency
4G/LTE (network-only)

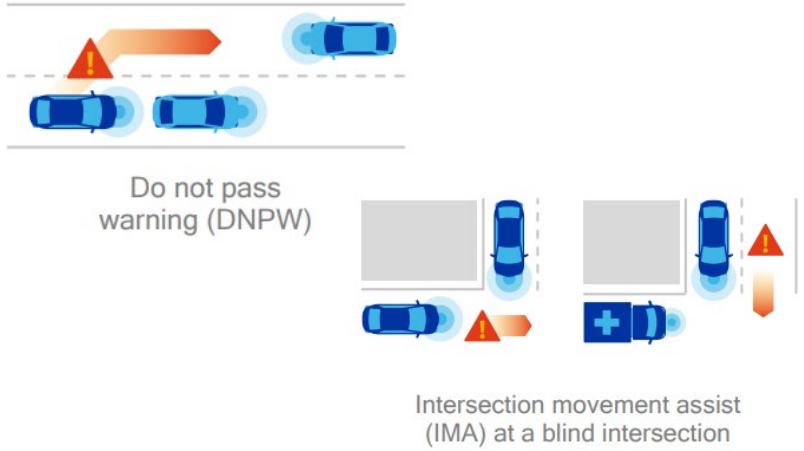
- Only using mobile networks (V2N)
- +30 million EU connected cars*
  - Local Hazard Warning
  - Traffic Info (in some



** Services provided depend on the OEM*

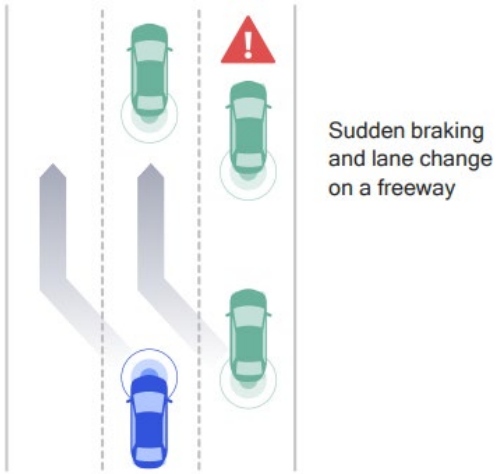
Basic & Enhanced Safety
LTE-V2X (+ direct short-range)

- C-V2X direct communications (V2V/V2I)
- China first-mover: 13 OEMs (2020/2021)
- US deployment announced 2022 (Ford)
- Audi US initial deployment Q3/2020

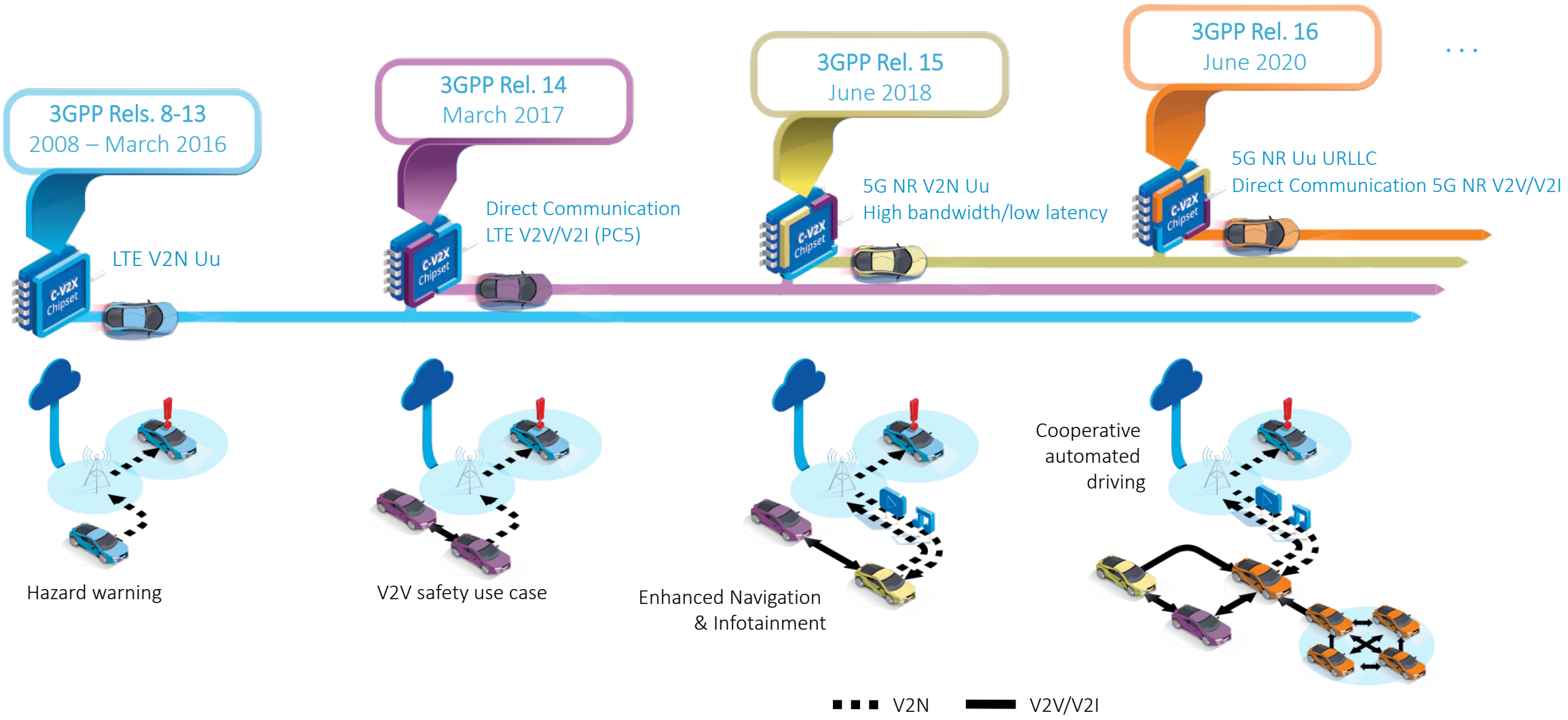


Autonomous Driving
5G-V2X enhancing ADAS

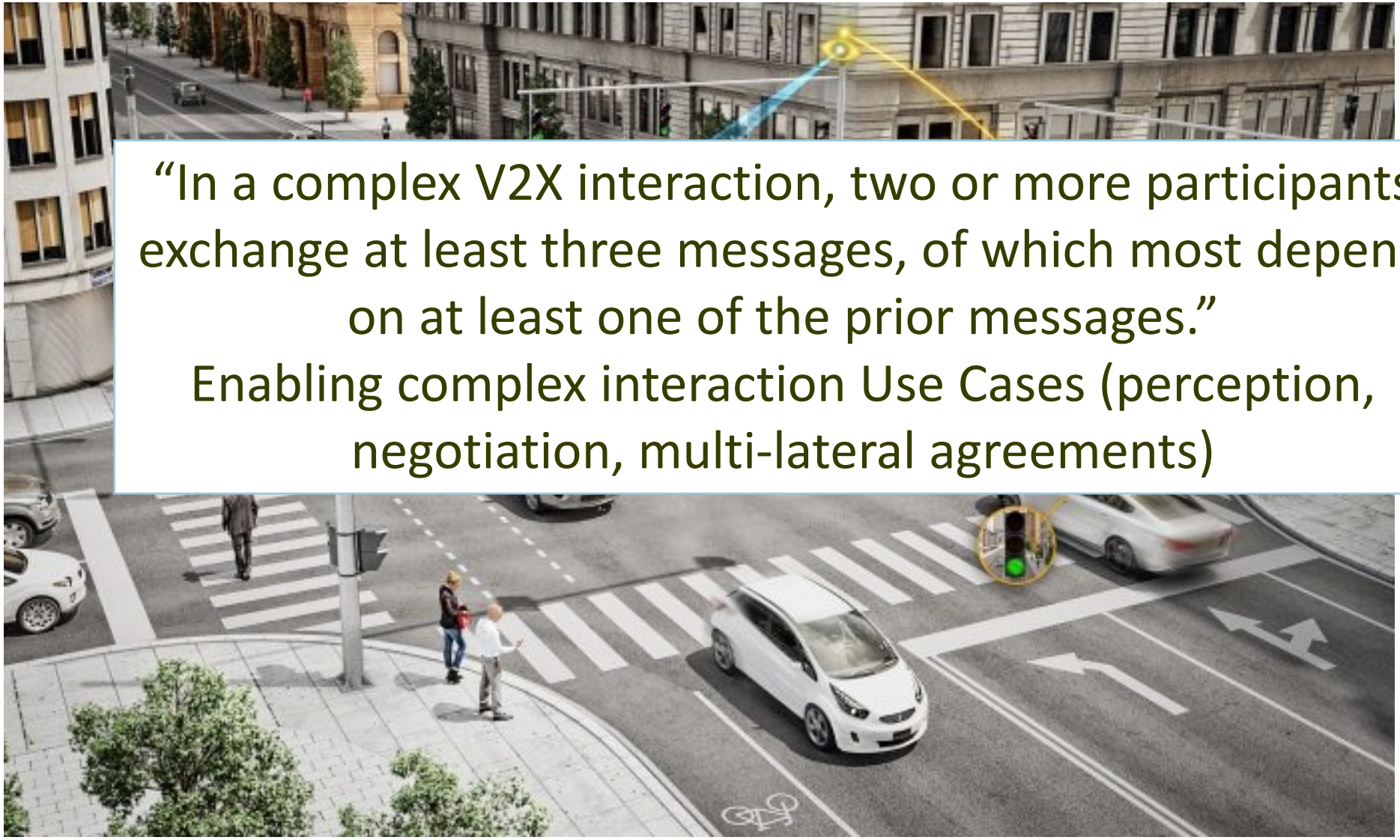
- Direct & mobile network communications
- Backward compatible with LTE-V2X
- Ultra-reliable at low latency (<1 millisecond)
- Almost unlimited data exchange



C-V2X: Evolution to 5G maintains backward compatibility



Enable complex interaction Use Cases (perception, negotiation, multi-lateral agreements)



"In a complex V2X interaction, two or more participants exchange at least three messages, of which most depend on at least one of the prior messages."

Enabling complex interaction Use Cases (perception, negotiation, multi-lateral agreements)

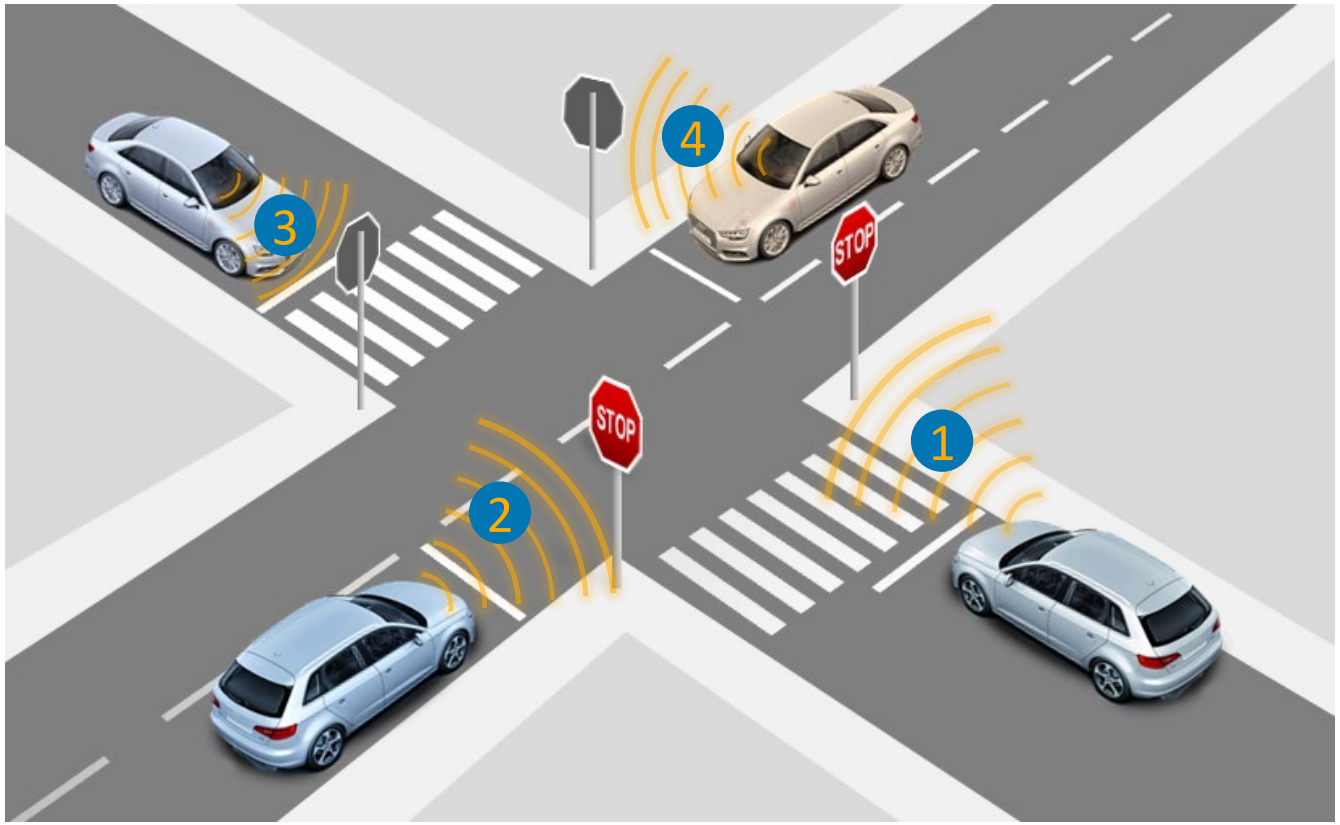
Source: Continental

Use Cases with Complex Interactions (a)

- Examples
  - **Cooperative Lane Merge (Use Case)**
  - Interactive VRU Crossing (Revamped Use Case)
  - Cooperative Lateral Parking (New Use Case)

Advanced Cooperative Driving Demonstration at CES (2019)

Next-Level V2X: Cooperative Four-Way-Stop



https://www.nbcbayarea.com/on-air/as-seen-on/5G-Cellular-Could-Change-How-You-Drive_Bay-Area-504246962.html

Demonstration by Audi, Ducati, Ford and Qualcomm:

- Showcasing potential of advanced C-V2X communications
- Developing basic understanding of protocol requirements to enable interactions between vehicles engaged in cooperative maneuvers
- Building up hands-on knowledge for 5GAA work items