DERQ

SAFER, SMARTER ROADS USING AI & V2X

Applications for Smart Cities, Connected & Autonomous Vehicles

PROTECTING ALL ROAD USERS

LEADING SOFTWARE PLATFORM FOR ANALYTICS & CAVs

GLOBAL MIT SPINOFF FOCUSING ON AI FOR TRANSPORTATION, 22 FTEs / 5 PhDs

POWER FUTURE OF ROADS FOR SAFE & EFFICIENT MOVEMENT OF PEOPLE

REAL-TIME PREDICTIVE VIDEO ANALYTICS & COOPERATIVE PERCEPTION

ACTIONABLE ROAD SAFETY INSIGHTS AND CUTTING EDGE V2X APPLICATIONS

CUSTOMERS & SCALING DEPLOYMENTS ON 3 CONTINENTS

MIT STARTUP EXCHANGE

planetM

دبـــي الذكية SMART DUBAI

DERQ

AWARD-WINNING TECHNOLOGY

Recognized across the world as a leading AI, smart city, and AV innovator

techstars®

Top 11 Mobility Startups Globally – 2017 Cohort

TOGETHER FOR® SAFER ROADS

Winner – Top Road Safety Innovator 2020

SXSW

Winner – AI Start-up of the Year 2019

NORTH AMERICAN INTERNATIONAL AUTO SHOW

Winner – Smart City Award Detroit Auto Show 2019

FACTORY 1 2K19
Accelerating with Kapsch

Winner – Kapsch Factory1 Accelerator 2019

هيئة الطرق والمواصلات
ROADS & TRANSPORT AUTHORITY
RTA

Finalist – Dubai World Challenge for Self-Driving Transport 2019

GULF TRAFFIC
TECHNOLOGY FOR SMARTER CITIES

Winner – Gulf Traffic ITS Product of Year 2018

LACoMotion

Winner – Autonomous Vehicles Category 2018

Automotive

Winner – AI Start-up of the Year 2018

ITS AMERICA

Finalist – Best of ITS Award 2018

NEXT CHALLENGE
smart cities 2017

People's Choice Award – NextChallenge 2017

NVIDIA
INCEPTION PROGRAM

Member – NVIDIA Inception program

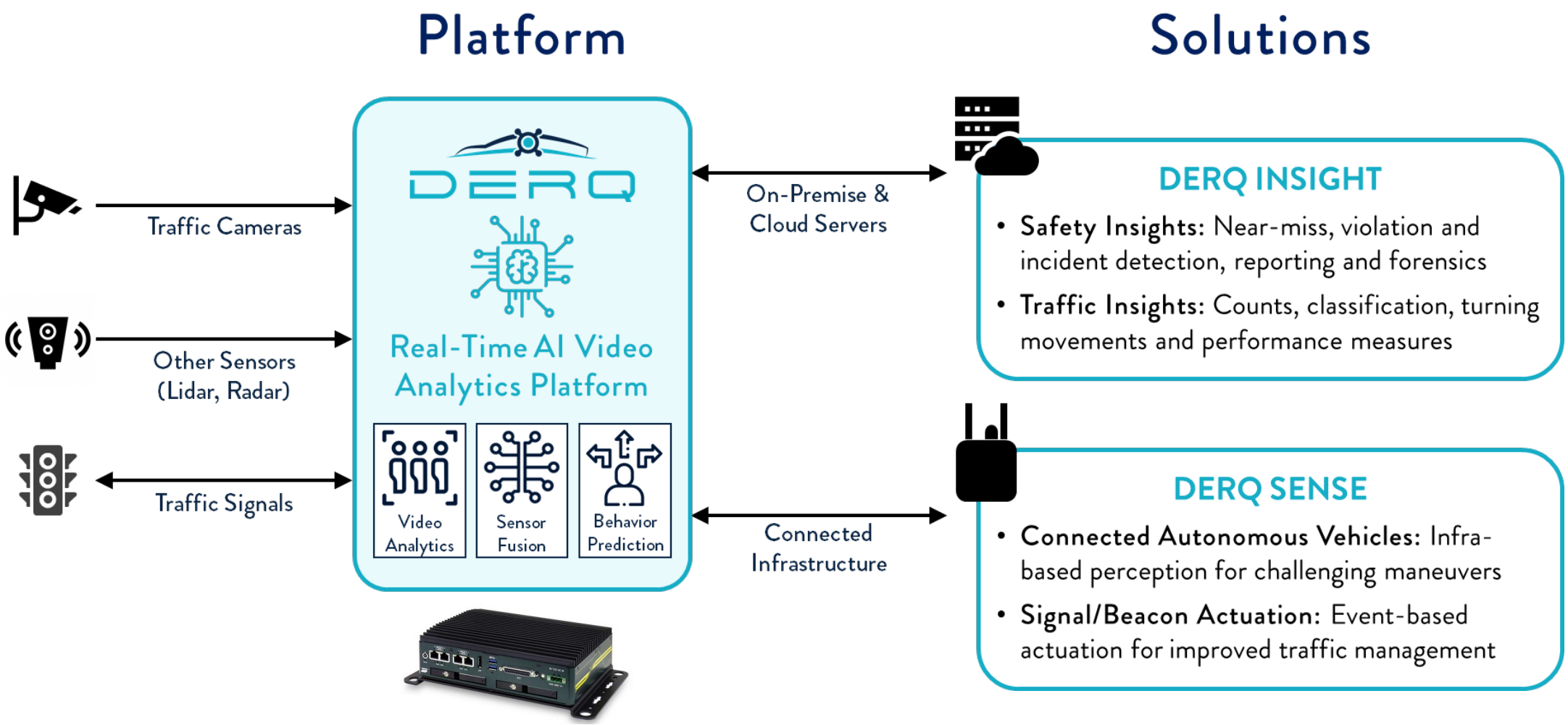
Qualcomm Smart Cities Accelerate 2021

DERQ

TECHNOLOGY PLATFORM

REAL-TIME AI ANALYTICS & CAV PLATFORM

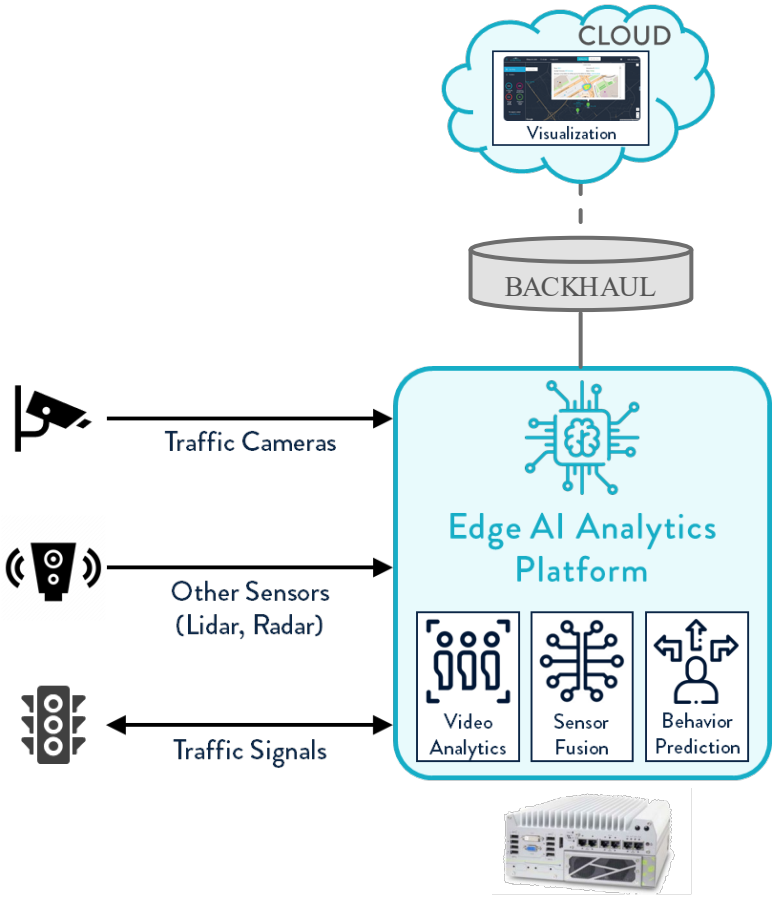
Software analytics platform for advanced solutions for Traffic Management and CAVs



FLEXIBLE PLATFORM

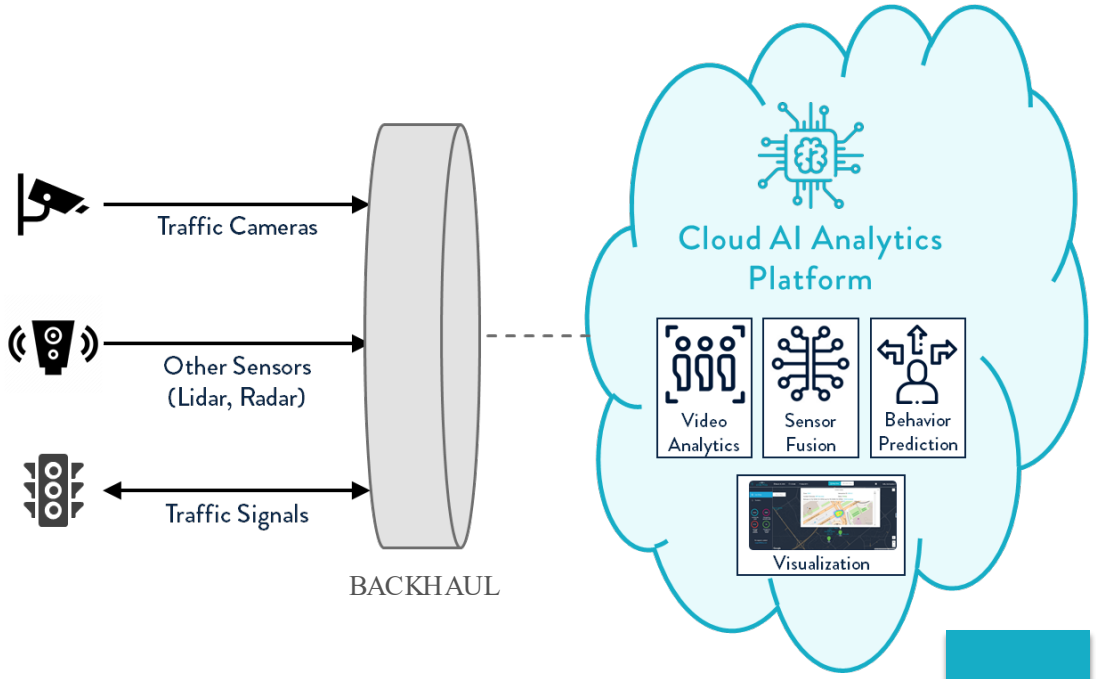
Platform that can suit each setup and needs

DECENTRALIZED



HYBRID

CENTRALIZED



Intent and Prediction ENGINE

Detecting, Tracking, Classifying road users and Predicting their intent in real-time

Analytics and CV ENGINE View

Detecting, Tracking, Classifying road users and Predicting their intent in real-time

```
280777545584 speed: 1.24786400794983 heading: 217.504623413086
[2019-07-17 15:04:57.934814] [0x00007fbbe6635700] [trace]   time: 1563361497.93477 latitude:
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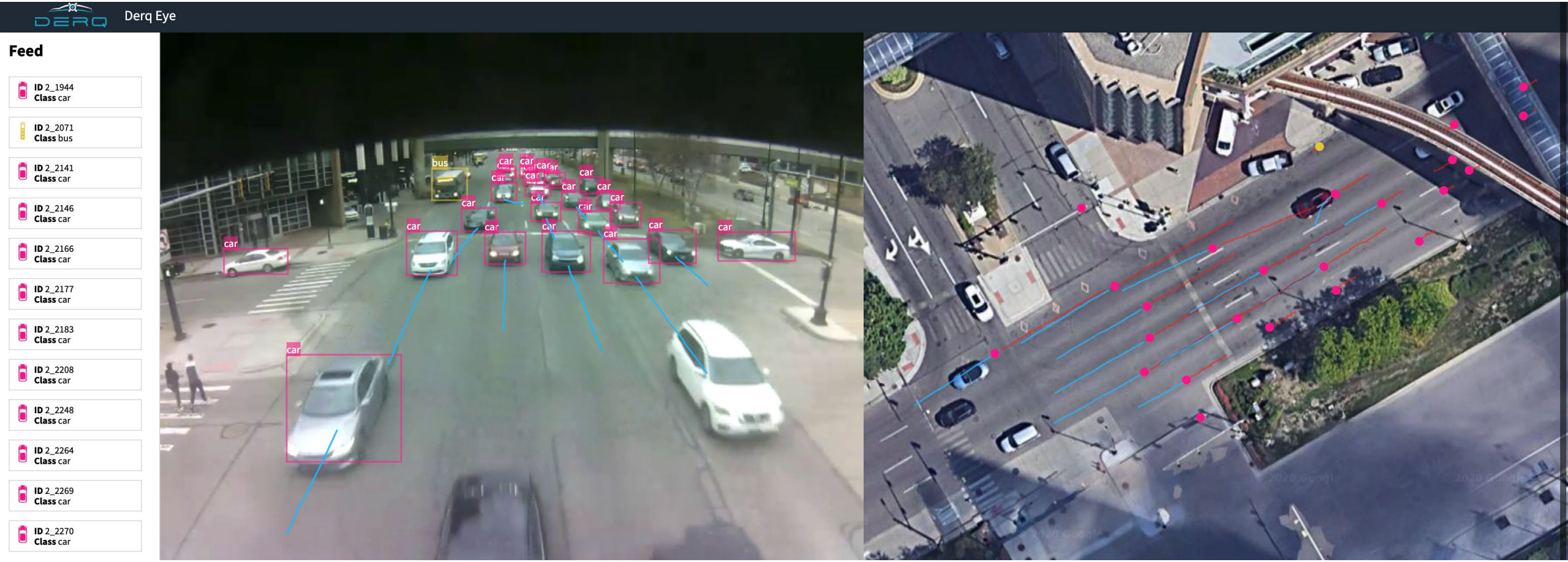
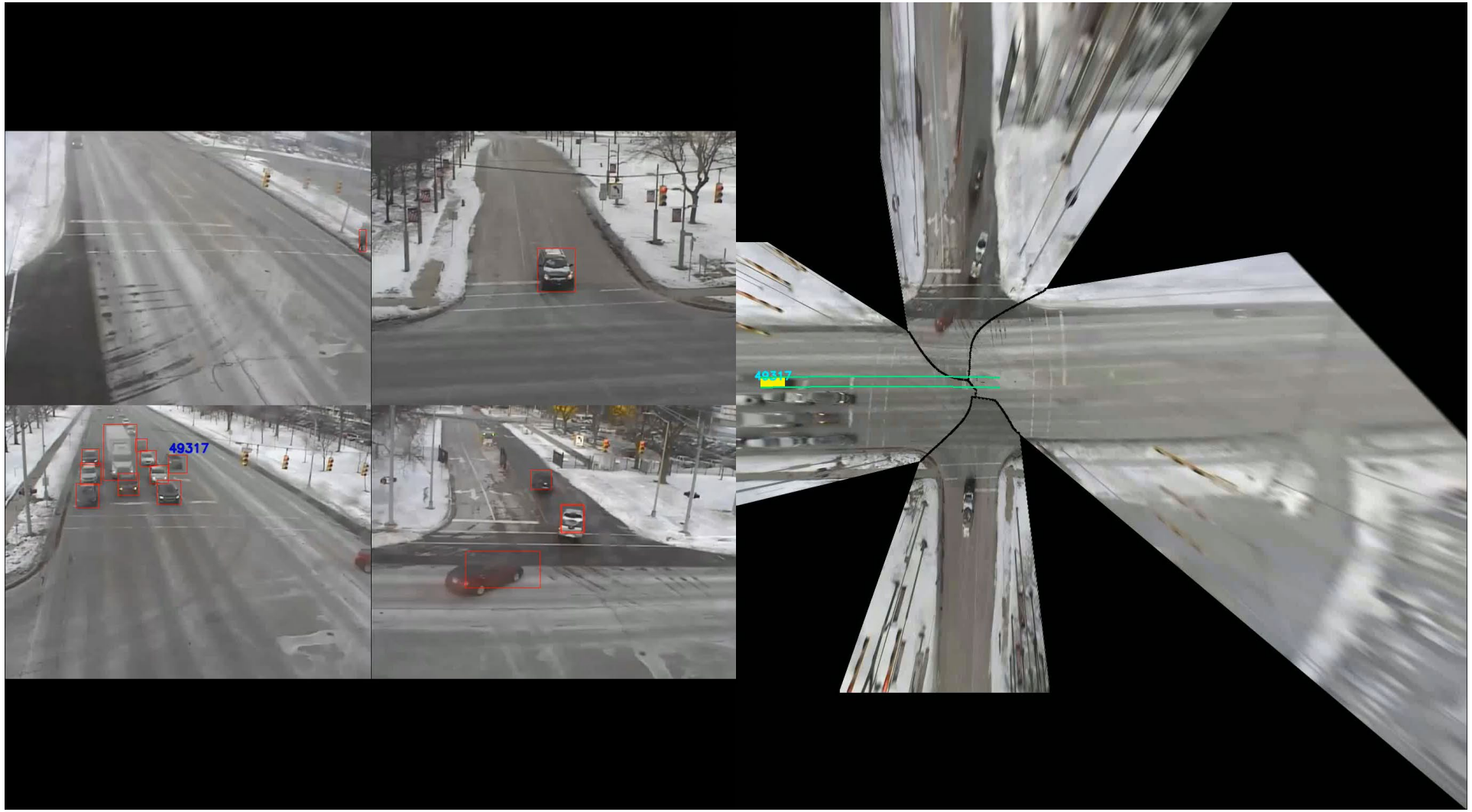
Perception ENGINE

Detecting, Tracking, Classifying road users



PERCEPTION SYSTEM – ANALYTICS ENGINE

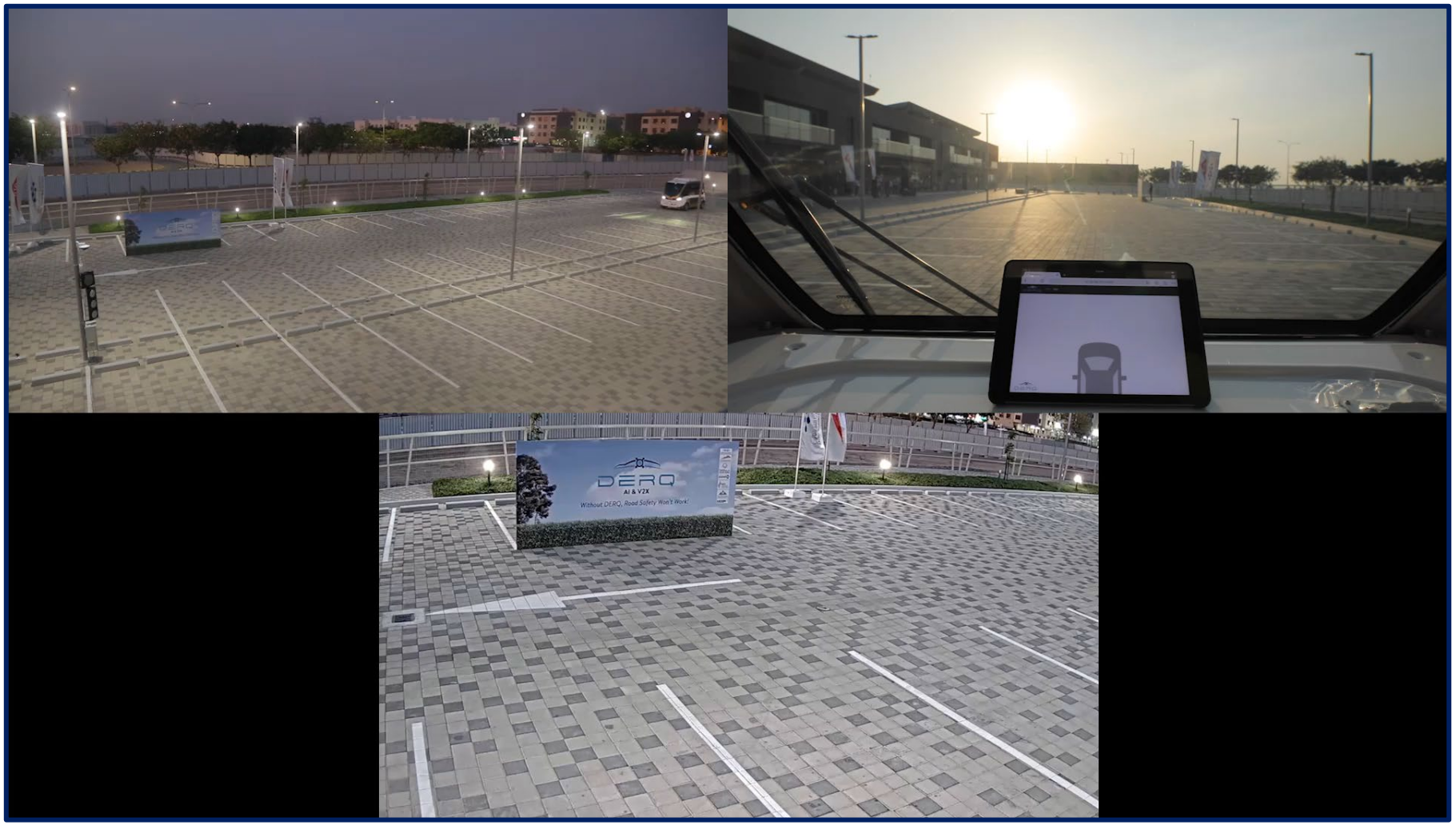


SMART PEDESTRIAN & VRU CROSSING

AI processes camera feeds in real-time, predicts VRU intents, and triggers the signs

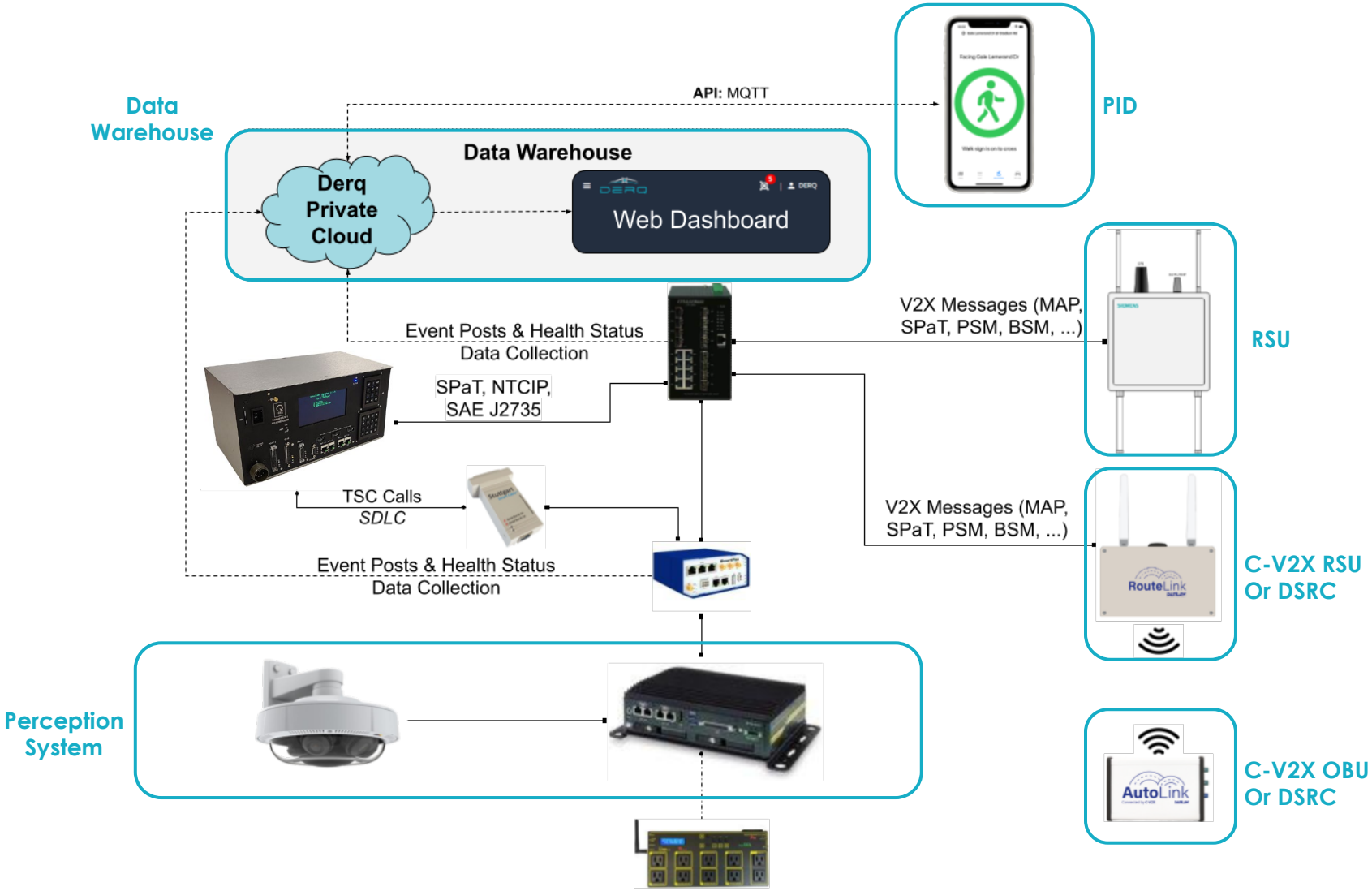
V2X FOR SELF-DRIVING VEHICLES

AI supporting CAVs to detect pedestrians & communicate intent to cross

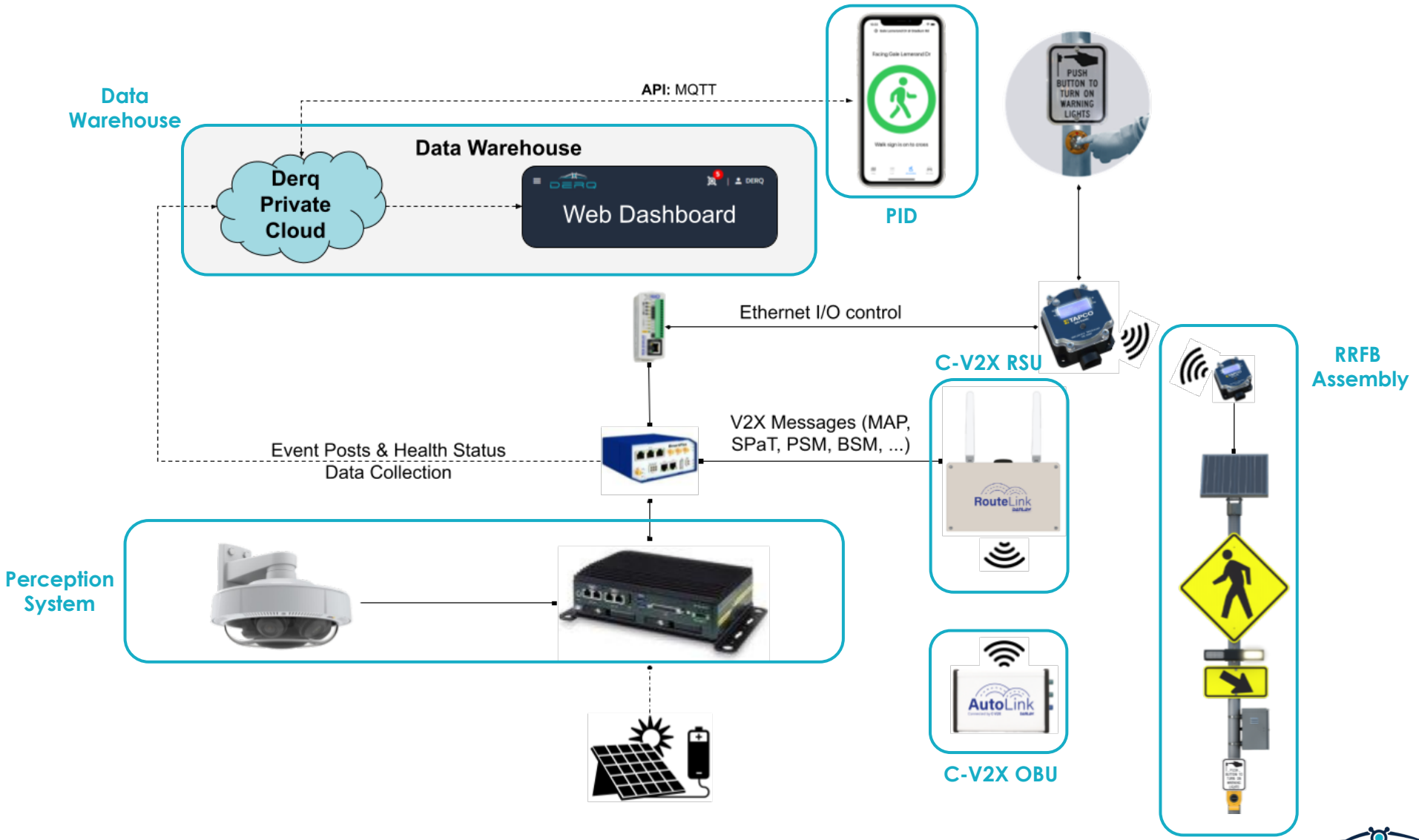


TECHNICAL & FUNCTIONAL SOLUTION

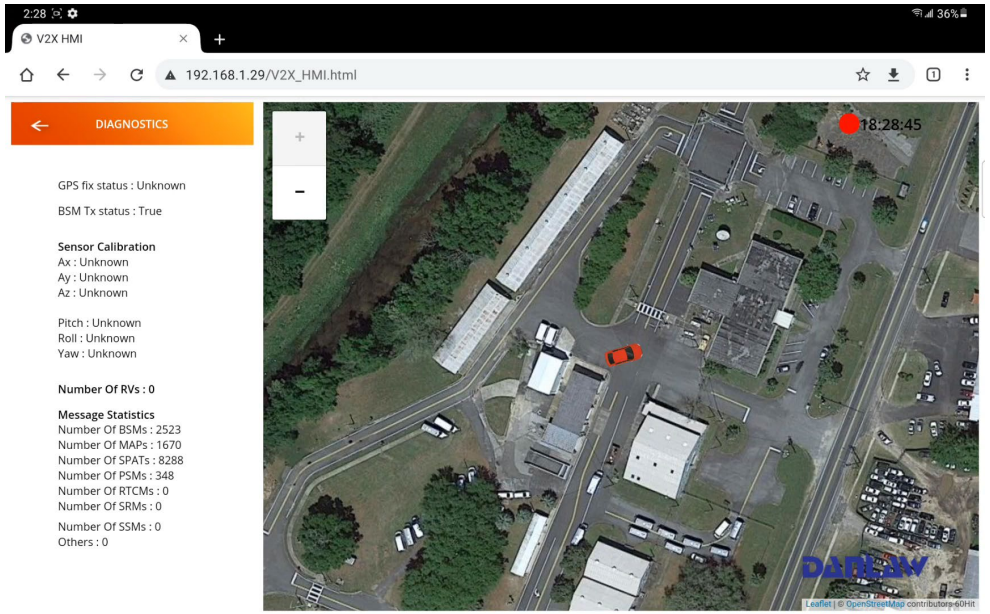
SIGNALIZED INTERSECTIONS – OVERALL SYSTEM ARCHITECTURE



MIDBLOCK CROSSINGS – OVERALL SYSTEM ARCHITECTURE



ON-BOARD UNIT APPLICATION



PED/BIKE SAFETY CV

- **Pedestrian Warning to Vehicle Using RRFB Activation by Passive Pedestrian Detection (PPD)**

Pedestrians/Bicyclists/Other NMTs presence identified by PPD:

- When Pedestrian/Bicyclist/Other NMTs are detected by the PPD system in or near the mid-block crosswalk, the presence is notified to the vehicles via OBUs through RSUs, and the RRFB is activated.

PED/BIKE SAFETY CV

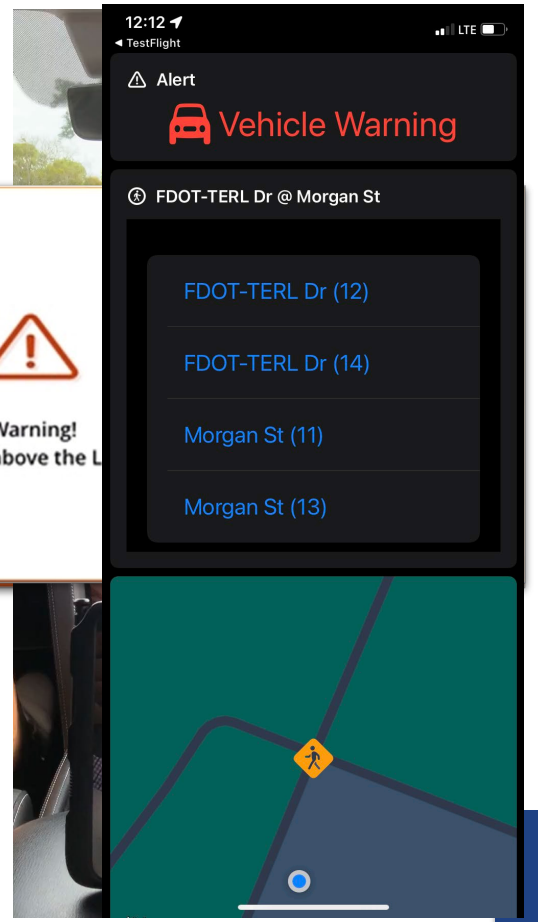
- **Vehicle Alert to the Pedestrians/Bicyclists/Other NMTs via OBU**

OBU advisor speed display:

- When a driver approaches the signalized intersection with an enabled RSU within the project area, the OBU provides the advisory speed on the in-vehicle display to warn the driver that they are above the speed.

pedestrian phase is activated.

- The RSU sends a message to the Vehicle OBU.



QUESTIONS?

JAMIE@DERQ.COM
WWW.DERQ.COM

SUPPORTING SOLUTION SLIDES

PID APPLICATION OVERVIEW

[OCTAVIO JONES | Tampa Bay Times]

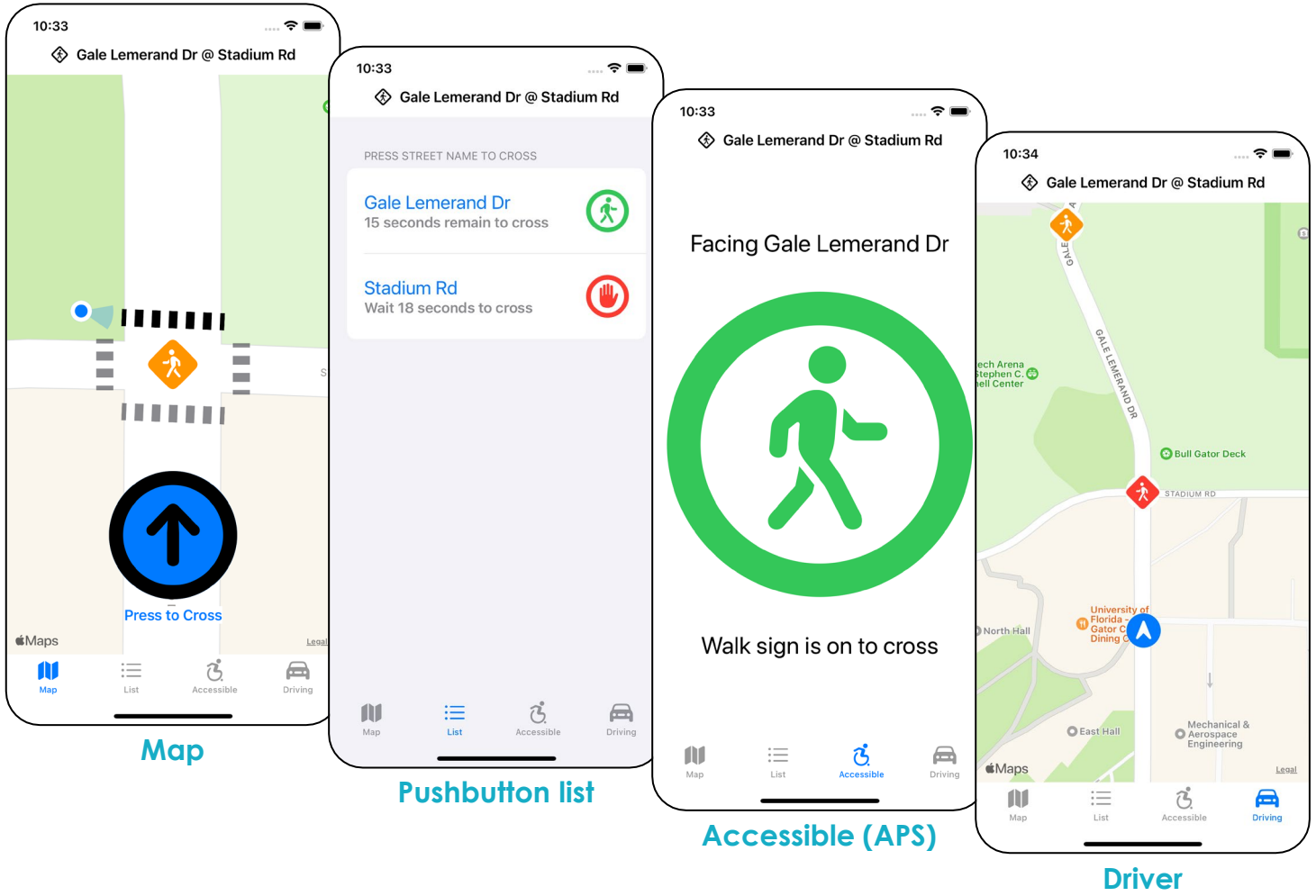
Key Features:

- Based on **CēVē driving app**
- Supports **open standards** for **interoperability**
  - J2735/JSON over MQTT/WebSocket/TLS
- Provides **user privacy** through random identifiers
- Provides robust security through **standards-based authentication**, **encryption**, and **anti-spoofing**
- Distributed via **Apple App Store** and **Google Play Store**

Key Features & Capabilities	
Android + iPhone	✓
Geofence detection	✓
Pedestrian warning to vehicle	✓
Vehicle alert to pedestrian	✓
Request pedestrian phase	✓
Advise driver of crosswalk	✓

PID APPLICATION USER EXPERIENCE

Four UX choices for users



Most PID use will be passive

- Geofence activation
- Automatic mode detection
- Visual, audible, and haptic notifications

Customizations with FDOT partners

- Define usage scenarios
- Perform user research
- Conduct usability testing
- Develop Human Use Plan
- Track app usage

PID APPLICATION FOR CYCLISTS

Notifications to Bicyclists in the Roadway or Bike Lane

The proposed system indicates that bicyclists in the roadway or bike lane may not receive notifications of approaching vehicles. The Vendor shall propose a solution for notifying these vulnerable road users when they are in the traffic stream.

Detection

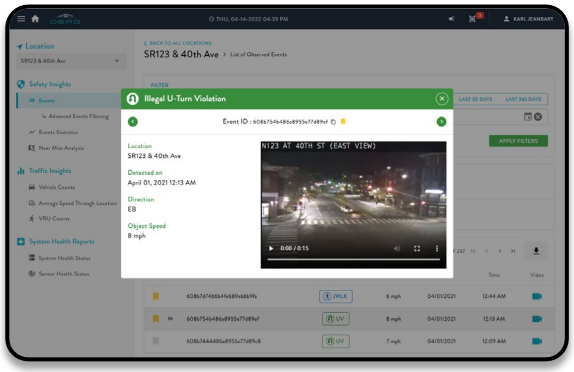
- Smartphone GPS might not be accurate enough for lane-level localization
- Derq's system can detect NMTs and fuse the data with PSMs received from the PIDs

Notification

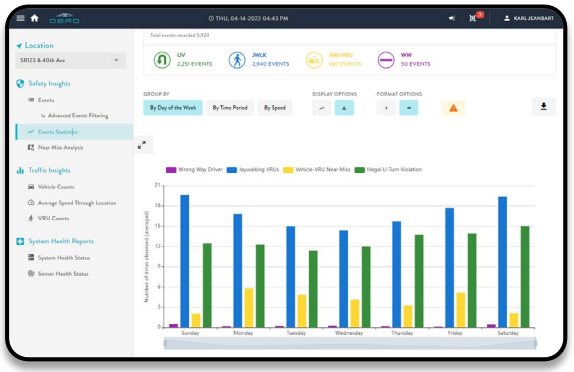
- PID display mounted on the handlebar
- Bluetooth speaker mounted or worn
- Wearable (Apple Watch) with audio + haptic feedback

DATA WAREHOUSE USER INTERFACE (1/2)

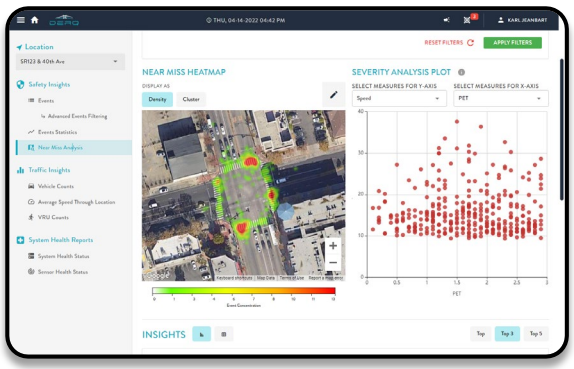
Derq's Safety and Traffic Insights Platform



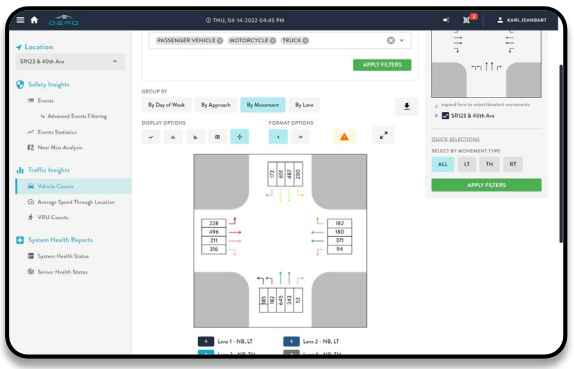
Individual Event Reports



Statistical Reports



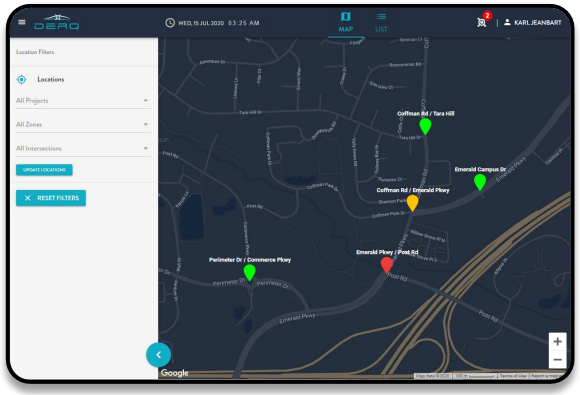
In-Depth Analysis Reports



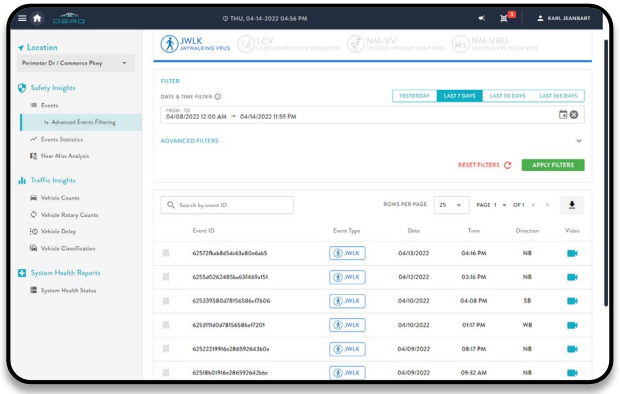
Traffic Count Reports

- **Safety Insights:** Real-time identification, reporting, classification, heatmaps and forensic analysis of the following events:
  - **Traffic conflicts** and **near-misses**
  - **Traffic violations**, including red light violations, wrong-way driving, illegal turning maneuvers, stopped vehicles and lane compliance
  - **Pedestrian compliance issues**, including illegal crossings and pedestrian signal violations
- **Traffic Insights:**
  - Traffic counts (lane-level, classified, turning movements)
  - Intersection capacity utilization, occupancy, density
  - Travel speeds

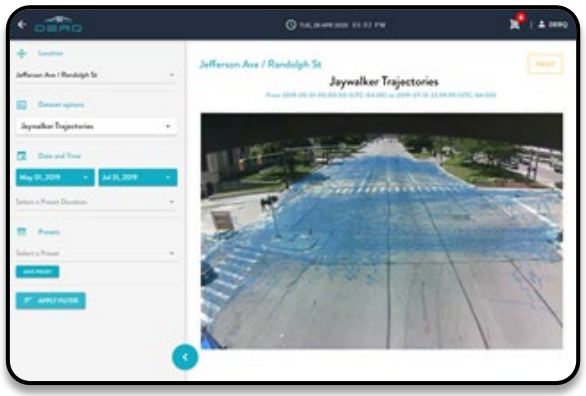
DATA WAREHOUSE USER INTERFACE (2/2)



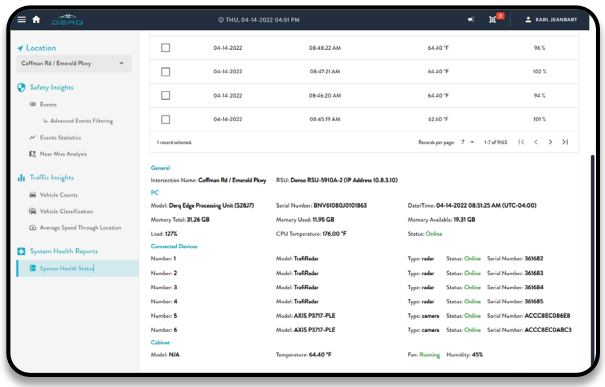
Quick Navigation Deployment Overview



Analyze data related to vehicles, VRUs, or both



Plot vehicle, VRU trajectories using spatial-temporal filters

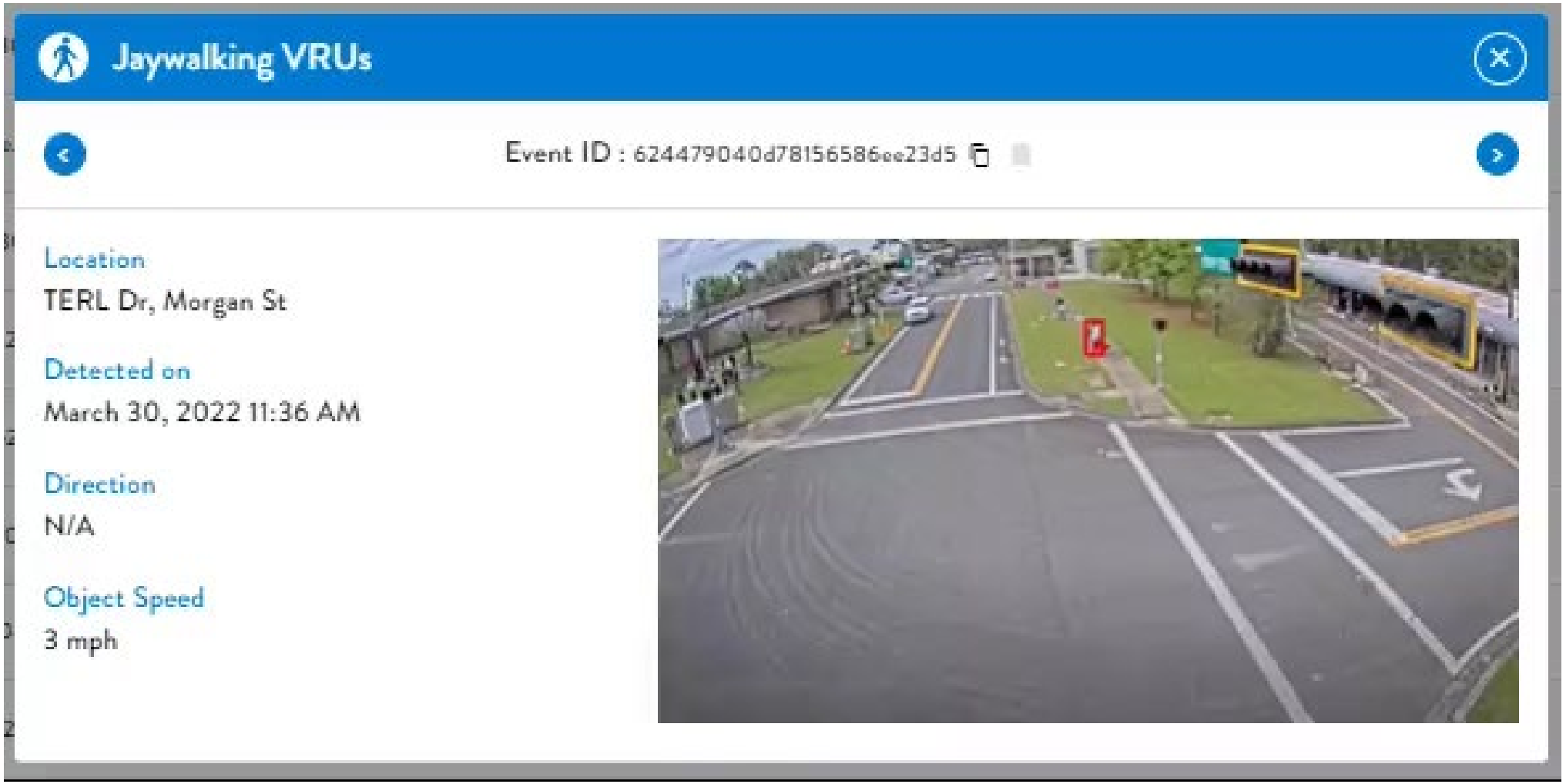


Check on hardware performance to ensure the system is up and running

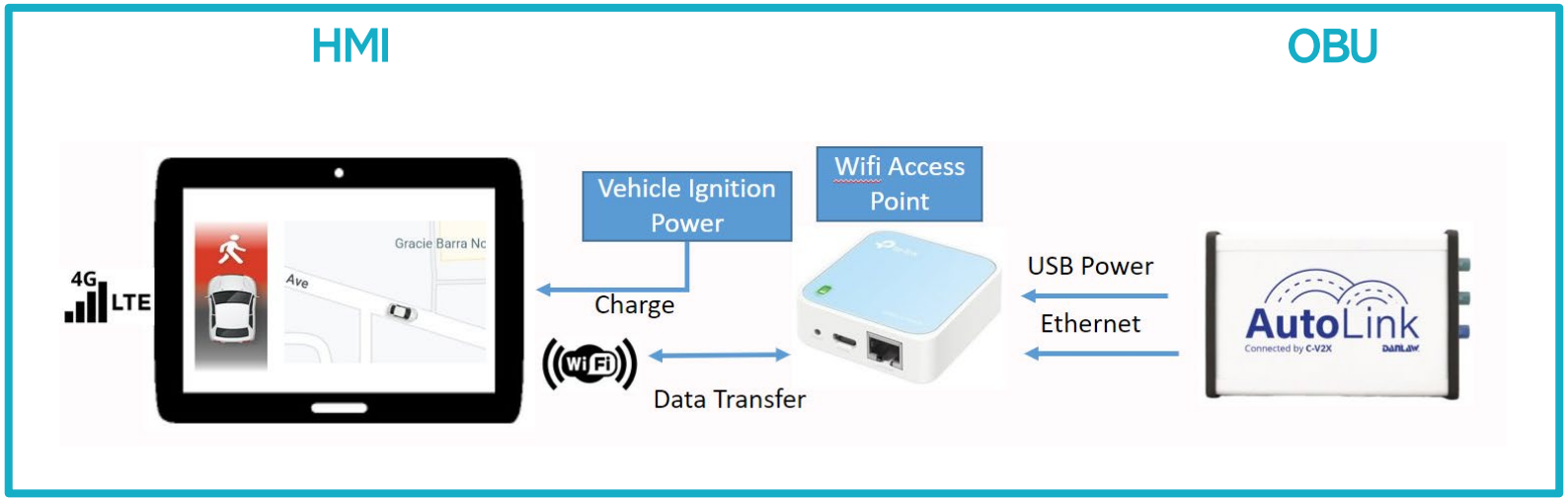
Key Features:

- **Single interface** for all data visualization, in-depth analysis and system monitoring
- **Encrypted** data **storage** in private network
- **Robust architecture** designed for **high availability** and **disaster recovery**
- **Secure** user access management with **MFA**
- **APIs** to interface with **third-party systems (e.g., ATMS)**

DATA WAREHOUSE DEMO



C-V2X IN-VEHICLE EQUIPMENT & APPLICATIONS



Applications

SPaT

Pedestrian Alert

Speed Compliance

Red Light Violation Warning

Key Features:

- Dual 5.9 GHz radios
- GNSS receiver
- 6-axis inertial sensor
- OBDII or CAN vehicle interface

Key Features & Capabilities	
Supports all messages per J2735 & J2945/1	✓
Integrated HSM	✓
Secure Remote Updates over the FDOT CV intra-network	✓
Secure Provisioning in the field	✓
Identity Certificates	✓
Equipped to support 4G LTE	✓

PERCEPTION SYSTEM (1/2)

AI PERCEPTION AND CONNECTIVITY ROADSIDE EDGE UNIT

Key Features & Capabilities:

- **Road User Detection, Tracking, Classification:**
  - **Advanced AI-powered computer vision** for vehicle and pedestrian detection
  - Real-time road user **localization**
  - **Sensor fusion** (multi sensor, multiple camera tracking)*
  - Road user **movement and intent prediction***
- **Communication with infrastructure and road users:**
  - **Two-way** controller communication (SNMP, HTTP, SDLC)
  - C-V2X message **generation** (proxy BSM, proxy PSM)*
  - C-V2X received message **processing and filtering***
  - **Real time IoT message** delivery through MQTT (QoS 2)
  - Event **posts** and reports to **dashboard**
- **Remote Management:**
  - **Remote monitoring** with health and status checks
  - **Remote configuration**
- **Ruggedized; Meets NEMA TS2 and FCC standards**

*Features protected by patents

PERCEPTION SYSTEM (2/2)

Camera

- **Panoramic** FOV
- **Night vision** with IR
- Network connectivity

Other Sensors

- Radar
- Lidar

Achieved FOV at intersections

Achieved FOV at midblock crossings

Key Features & Capabilities	
Detects, Tracks, Classifies Vehicles	✓
Detects, Tracks, Classifies VRUs	✓
Monitors approaches and crosswalk in each direction	✓
Sends vBSM to RSU when vehicle approaching	✓
Sends vPSM to RSU when VRU in crosswalk	✓
Calls pedestrian phase at TSC when VRU detected at signalized intersections	✓
Activates RRFB when VRU detected at mid-block crossings	✓

C-V2X ROADSIDE EQUIPMENT

RSU

Key Features:

- Messages Supported (J2735):
  - WSA broadcasts
  - **SPaT** and **MAP** messages
  - **BSM** / **proxy BSM** messages
  - **PSM** / **proxy PSM** messages
  - Traveler information messages (**TIM**)
  - Roadside alerts (RSA) messages
  - Signal Status messages (SSM)
  - Signal Request messages (SRM)
- **Local** or **Remote** antenna configurations
- Compatible with **ISS SCMS provider**

Key Features & Capabilities	
Supports all messages per J2735 & J2945/x	✓
FDOT Provider Service Identifiers (PSID) – Service Specific Permissions (SSP) Profile support	✓
3GPP Release 14	✓
Capable of Geofencing	✓
C-V2X Transmissions using 5.905 - 5.925 MHz	✓
Power over Ethernet port provided	✓
Support pseudonym certificates	✓
Integrated Hardware Security Module (HSM)	✓
Supports IPv6	✓
Secure Software/Firmware Updates over the FDOT CV intra-network	✓
Meets SNMP v3 MIB protocols	✓
PSID-SSP Testing Support	✓

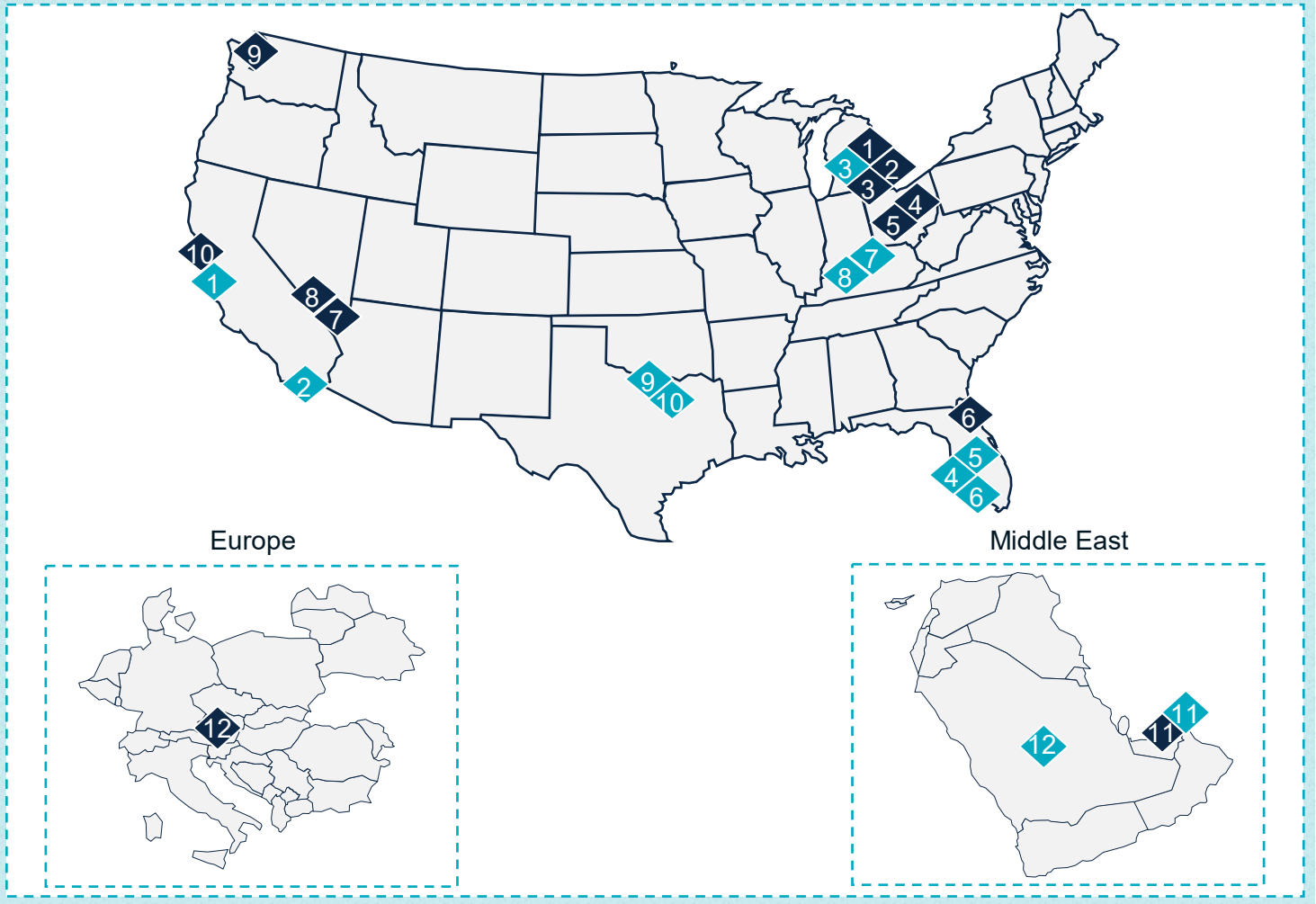
DEPLOYMENTS

LIVE DEPLOYMENTS AND PROJECTS

Live in 3 continents and 12 cities with an additional 12 deployments lined-up

Current Derq Deployments

1. Detroit, Michigan
2. Detroit, Michigan
3. Warren, Michigan
4. Marysville, Ohio
5. Dublin, Ohio
6. Jacksonville, Florida
7. Las Vegas, Nevada
8. Las Vegas, Nevada
9. Lynnwood, Washington
10. Oakland, California
11. Dubai, UAE
12. Vienna, Austria



Future Derq Deployments

1. Fremont, California
2. San Diego, California
3. Detroit, Michigan
4. Sarasota, Florida
5. Gainesville, Florida
6. Pinellas County, Florida
7. Louisville, Kentucky
8. Lexington, Kentucky
9. Dallas Fort Worth, Texas
10. North Texas Tollway Authority, Texas
11. Ajman, UAE
12. Riyadh, Saudi Arabia

M1 DEPLOYMENT – ONE OF LARGEST INTELLIGENT CORRIDORS IN US

$11M, 60+ intersections project to convert busy corridor into safer and smarter CAV corridor

Client

MDOT
Michigan Department of Transportation

Sponsor

U.S. Department of Transportation
Federal Highway Administration

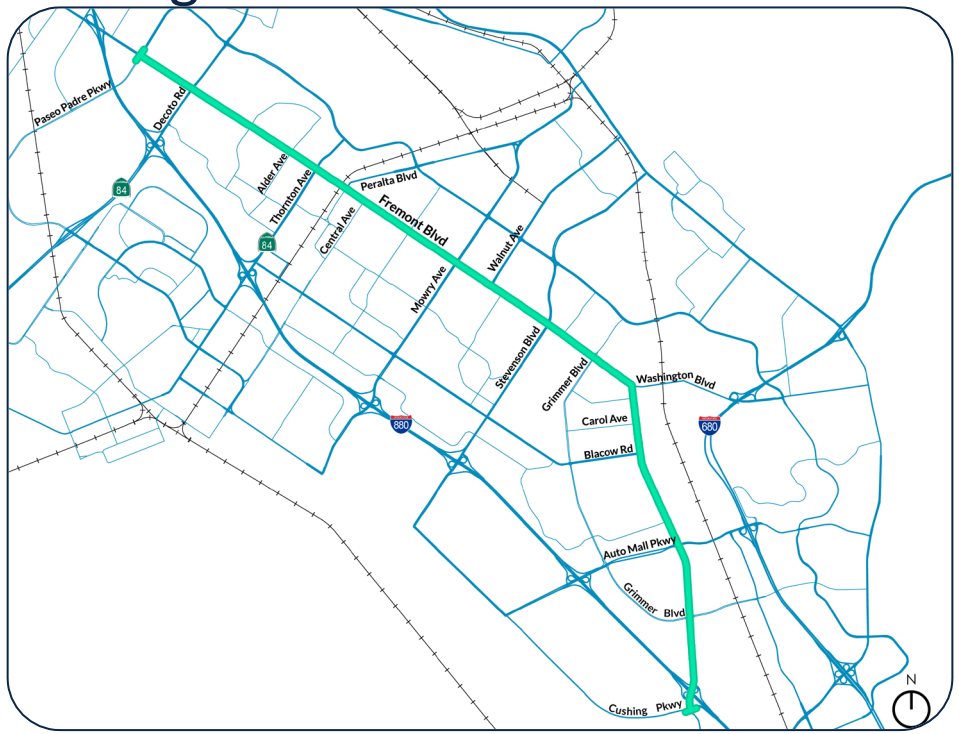
- 3-year project, $11M budget
- 65 Intersections along highly travelled corridor in Detroit
- Part of consortium of industry leaders
- Derq's edge AI platform integrated with partners' hardware for Insights and CAV applications

Partners

WSP
BOSCH
MH CORBIN
WAYNE STATE UNIVERSITY

FREMONT BOULEVARD SAFE AND SMART CORRIDOR PROJECT

37 Intersections, $10M+ Investment in Innovation and Technology for Corridor Management



Client

CITY OF Fremont California

Sponsor

ALAMEDA County Transportation Commission

Consultant

PARSONS

- 5-year project, $10M budget for innovative traffic management and V2X tech to enhance mobility and safety
- 37 Intersections, ±10-mile corridor, Phase 1 of 3
- Part of winning team of highly competitive bid
- Derq's edge AI platform deployed for Insights and CAV applications

Technology Partners

DERQ

CT CONTROL TECHNOLOGIES

Q-FREE INTELIGHT

ECONOLITE

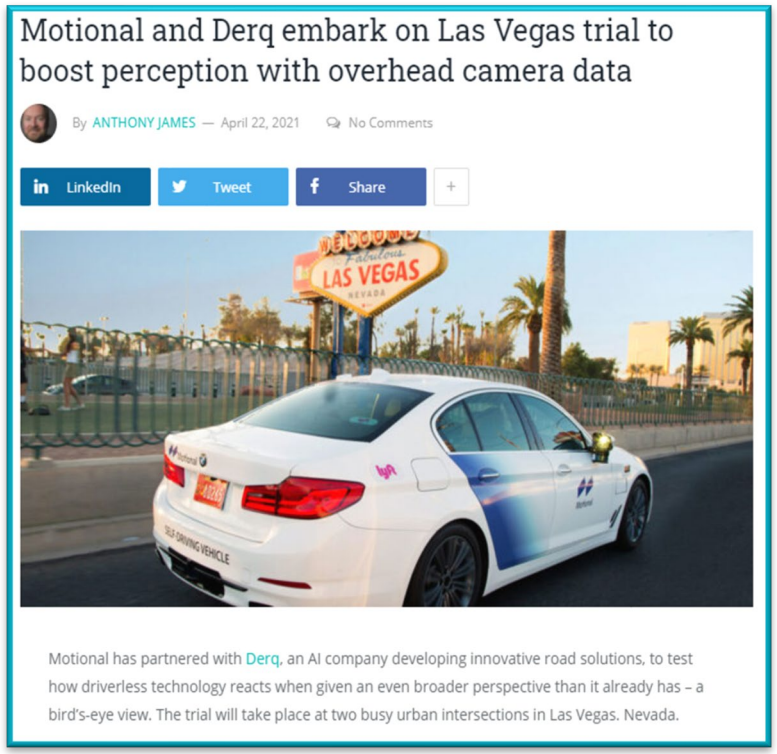
iteris

DERQ

Source https://fremontsmartcorridor.org/

MOTIONAL ($4B JV BETWEEN APTIV AND HYUNDAI) CASE STUDY

Pilot with Self-Driving Leader Motional: infrastructure perception by Derq Sense to improve driverless safety, performance, and comfort


Motional and Derq embark on Las Vegas trial to boost perception with overhead camera data

By ANTHONY JAMES — April 22, 2021 No Comments

LinkedIn Tweet Share +

Motional has partnered with Derq, an AI company developing innovative road solutions, to test how driverless technology reacts when given an even broader perspective than it already has – a bird's-eye view. The trial will take place at two busy urban intersections in Las Vegas. Nevada.

Pilot Phase 1 Offboard detection analysis

Pilot Phase 2 Real-time integration

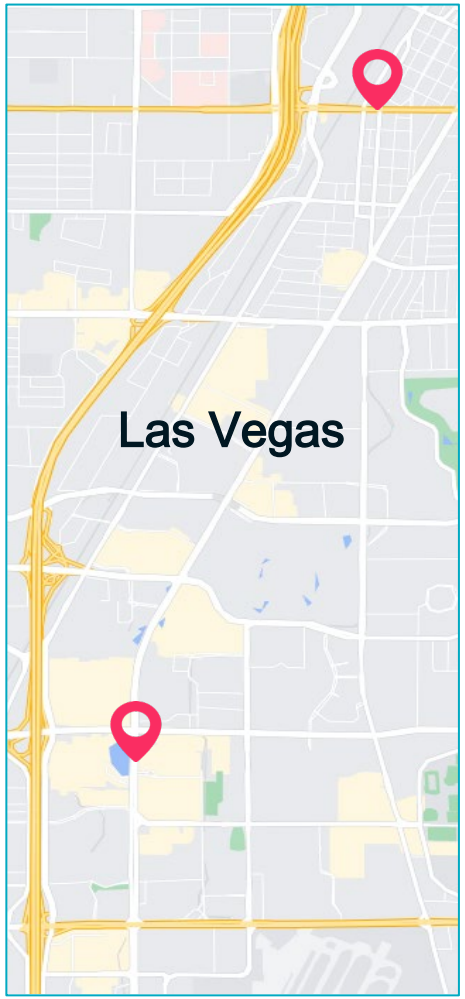
Pilot Phase 3 Additional routing benefits

- Strategic importance given Motional's lead position in the autonomous vehicle (AV) market
- Testing and integration with Motional AVs on key challenging locations in Las Vegas

"Derq's technology addresses a clear need in the autonomous vehicle (AV) market. Their smart infrastructure solution will contribute to the safe scaling of AV deployments, while also improving rider comfort."

- *Karl Iagnemma, President and CEO of Motional*

Trial Location



PROJECT WITH TELCO TO ENABLE AV SHUTTLE DEPLOYMENTS

Pilot with Etisalat in conjunction with the Ajman government to deploy Derq's AI Roadside Edge technology in autonomous shuttle feet

Use Cases

- Real-time communication to the autonomous shuttle of surrounding pedestrians and other vulnerable road users'
- Real-time communication to the autonomous shuttle of traffic signal phase information at signalized crossings

Role of Telco

- Access to customer and relationship management
- System integrator combining key tech building blocks
- Access to 5G and LTE communication infrastructure

Role of Derq

- Derq's AI Roadside Edge to process data from traffic sensors, signal controllers, and connected infrastructure
- Cellular-V2X for robust and very low latency point-to-point communication with AV

Pilot Location

In The Press

Look: New self-driving vehicle in Ajman to transport tourists from hotels to landmarks

The UAE leads the future of transportation and autonomous vehicles

'UAE-Driving the future of mobility and autonomous technology' – Etisalat

Ajman's self-driving shuttle bus hits the road

IMPLEMENTATION

SOLUTION IMPLEMENTATION

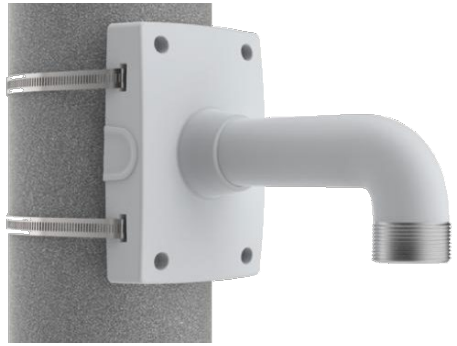
SIGNAL CONTROLLER – ADVANCED PEDESTRIAN FUNCTIONALITY

- **Advance Walk (Leading Pedestrian Interval (LPI)):** gives pedestrians a 3–7 second head start when entering an intersection with a corresponding green signal in the same direction of travel.
- **Negative Ped:** does not allow a programmed FYA to be serviced when the conflicting pedestrian phase is active (taking the possibility of a bad decision away from the driver). If the programmed FYA is in service and the Negative Ped is called, the FYA will terminate before the pedestrian phase can begin service.
- **No FYA During Walk:** does not allow a programmed FYA to be serviced when the walk of a conflicting pedestrian phase is active.
- **FYA Ped Delay:** delays the start of the FYA by a configured amount of time after the start of a conflicting pedestrian phase, providing the pedestrian an Advance Walk (LPI) before the FYA is active.
- **Walk Extension & Walk Max:** continue to add time to the programmed Walk, as long as pedestrian presence is detected, up until the programmed Walk Max is hit.

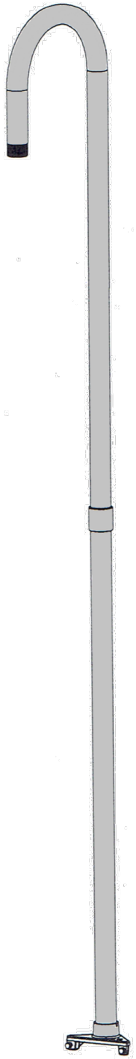
CAMERA INSTALLATION – MOUNTING HARDWARE

AXIS P3727-PLE
Network Camera*

AXIS T94N01D
Pendant Kit



AXIS T91B67
Pole Mount
(not required for all locations)



Candy Cane
Extension Pole
(not required for all locations)

AXIS T91B52
Extension Pipes
(if required)

Saddle & Swivel
Clamp Assembly
(Astro-bracket)

*Subject to change to equivalent models based on selected model availability and procurement lead times

EDGE DEVICE DIMENSIONS & INSTALLATION GUIDELINES

Recommended mounting locations in NEMA TS2 Type P cabinet

Dimensions:

- 9 in (W) x 6.8 in (D) x 2.6 in (H)

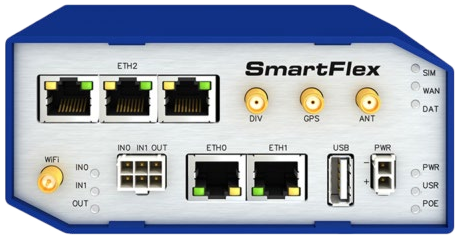
Recommended Installation:

- Shelf-top installation or mounted vertically on plate / din-rails (1.378" W or 35.00mm top hat din-rails)
- Enough clearance kept for adequate ventilation

Included Ancillary Electronics:

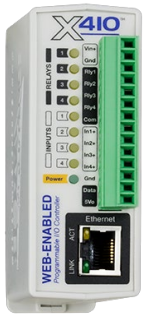
- Main power supply (plug-in AC/DC adapter or din-rail AC/DC converter)
- Fan kit (optional)

ANCILLARY ROADSIDE HARDWARE



LTE Router

- Three PoE ports
- WiFi Connectivity
- Allows for three subnets



Web I/O Controller

- Reliable watchdog
- Allows remote reboots
- Digital and analog I/O

Web-managed power strip

- Reliable watchdog
- Allows power control and remote reboots

RRFB Controller

- Wireless activation
- Push-button integration

SDLC Module

- Supports both TS/2(BIU) and ATC (SIU)

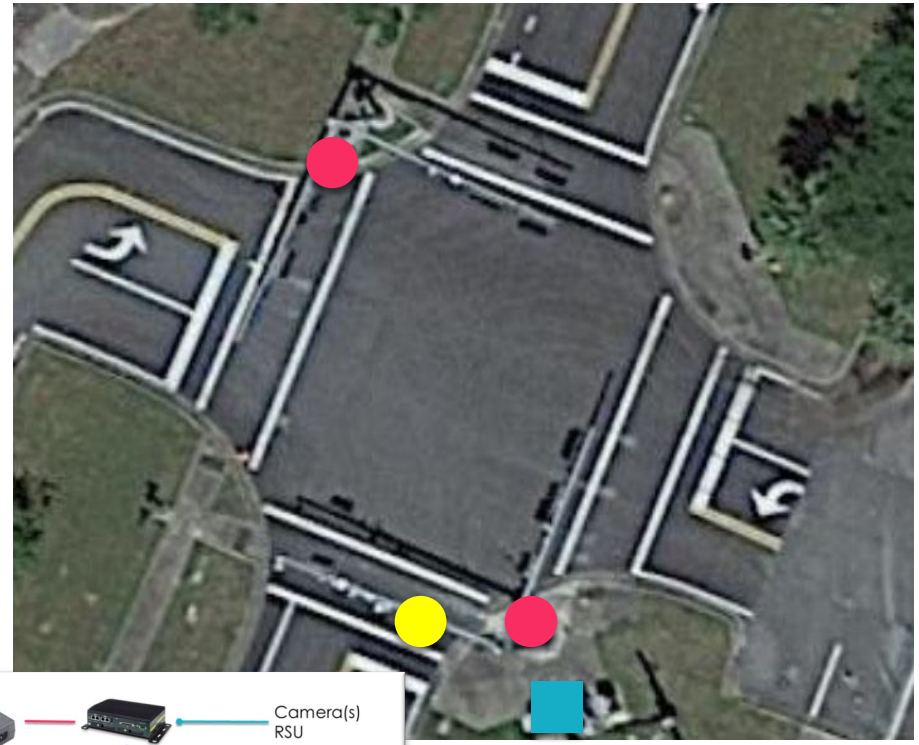
Requirements	
Remote Management	✓
TSC Pedestrian Calls	✓
Pushbutton Integration	✓

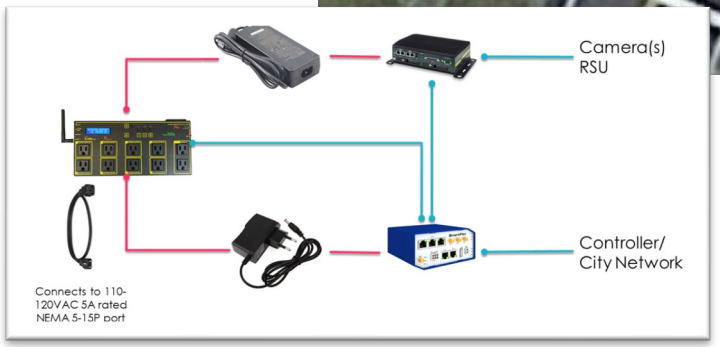
DERQ

INSTALLATION PLAN – INTERSECTIONS

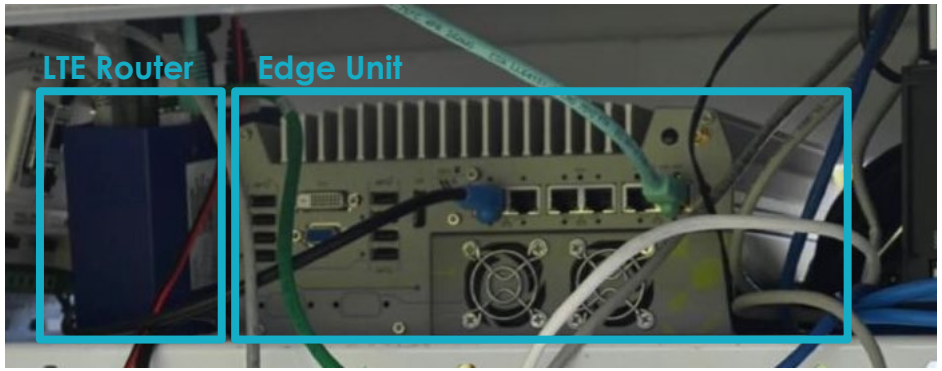
Sample Intersection Layout (FDOT-TERL Dr / Morgan St)

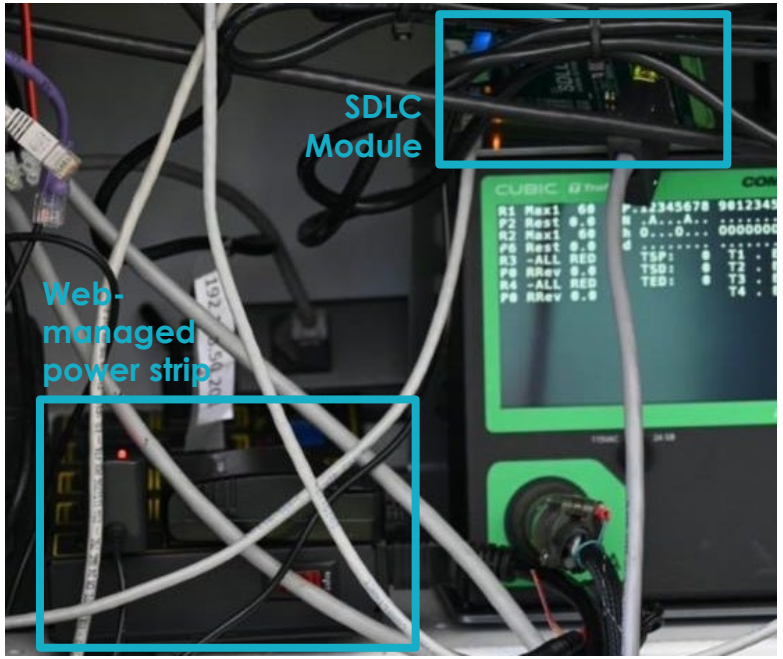
1. **Detection Cameras**
   - 2 x Multimodal 360 Network Detection Cameras Unit (RGB + IR)
   - Locations – On the mast arm
   - Connectivity – PoE/ Cat6 cable
2. **RSU**
   - C-V2X Road Side Unit
   - Locations – On the mast arm
   - Connectivity– PoE/ Cat6 cable
3. **Edge Processing Setup**
   - Inside Traffic Control Cabinet
   - Connectivity – Ethernet, LTE, WiFi
   - Power – 120V / 136W Max, NEMA 5-15P handoff from power source





INSTALLATION PLAN – EXAMPLE INTERSECTION FROM TERL

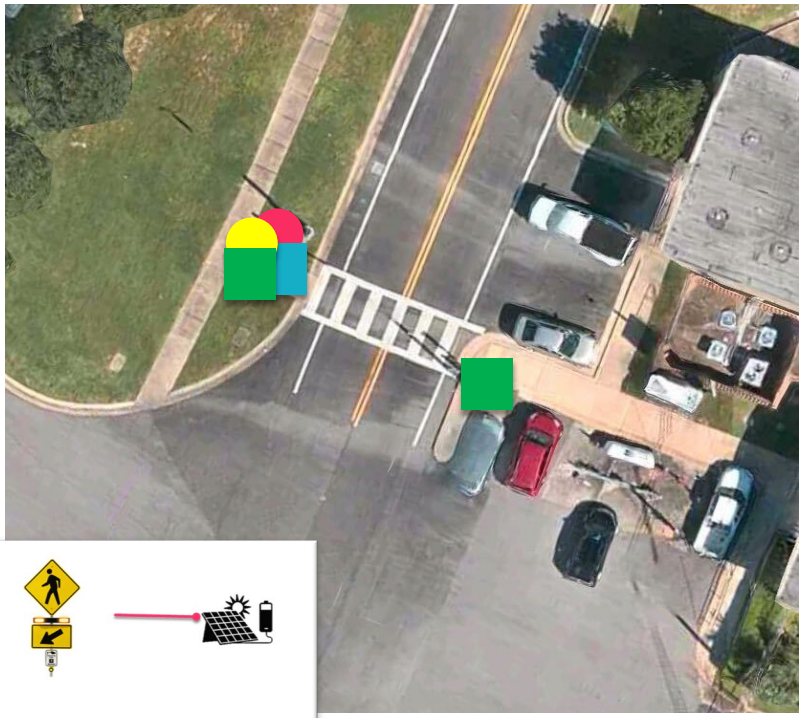


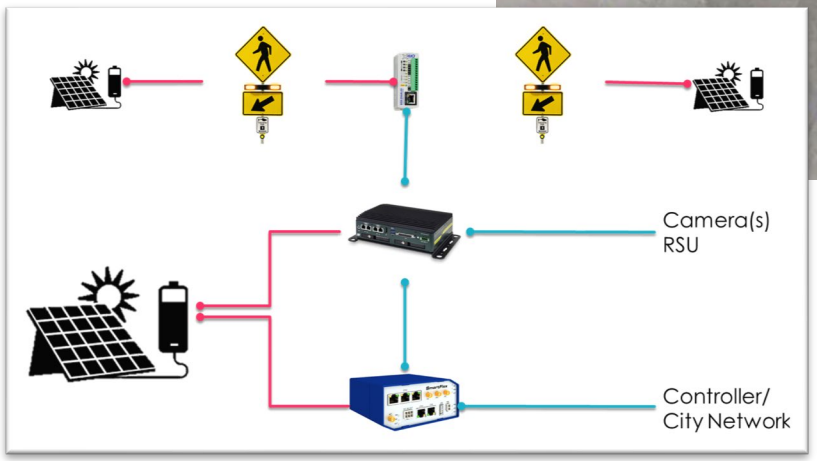


INSTALLATION PLAN – MIDBLOCK CROSSINGS

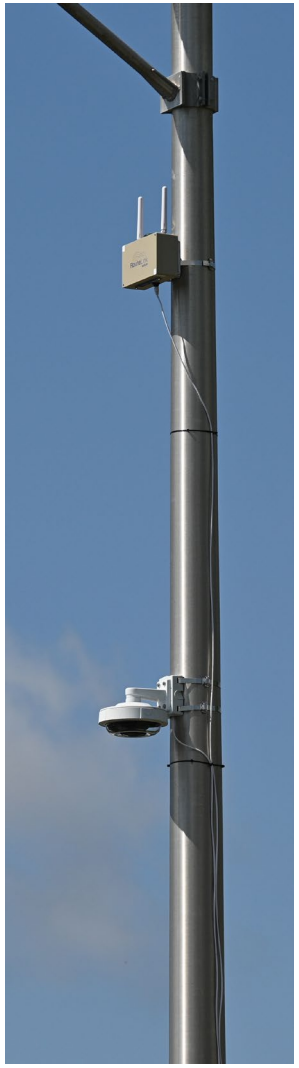
Sample Mid-Block Crossing Layout (FDOT-TERL Dr Crosswalk)

1. **Detection Camera**
   - Multimodal 360 Network Detection Cameras Unit (RGB + IR)
   - Locations – On the street light pole
   - Connectivity – PoE/ Cat6 cable from Edge Unit
2. **RSU**
   - C-V2X Road Side Unit
   - Locations – On the street light pole
   - Connectivity– PoE/ Cat6 cable from Edge Unit
3. **Edge Processing Setup**
   - Locations – Inside RRFB cabinet
   - Connectivity – Ethernet, LTE, WiFi
   - Power – Solar
4. **RRFB**
   - Rectangular Rapid Flashing Beacon
   - Locations – On the street light pole
   - Power – Solar



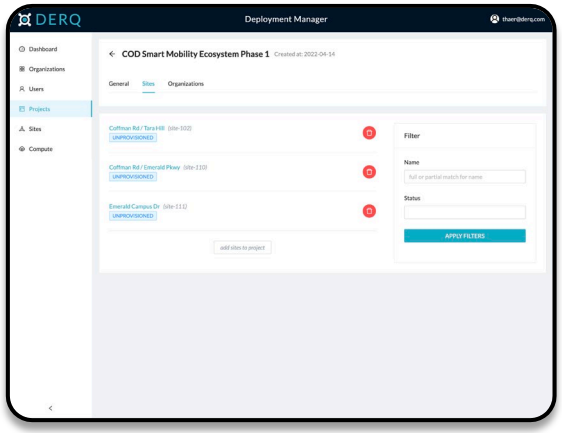


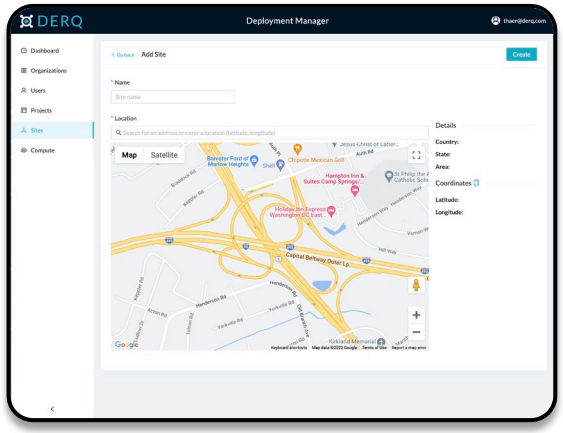
INSTALLATION PLAN – EXAMPLE MID-BLOCK FROM TERL

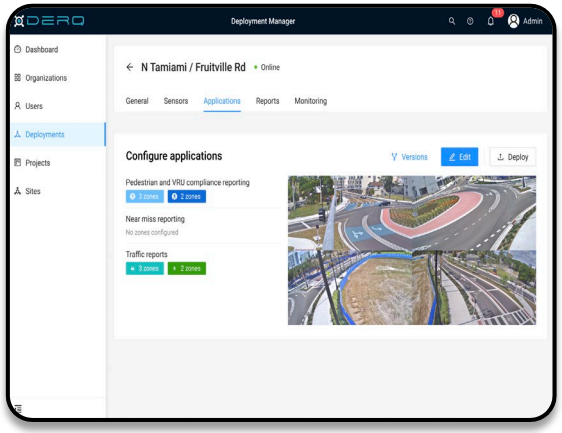


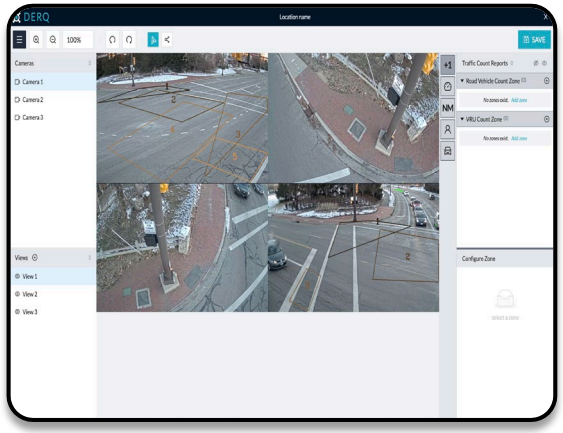
SYSTEM COMMISSIONING

Derq Deployment Manager

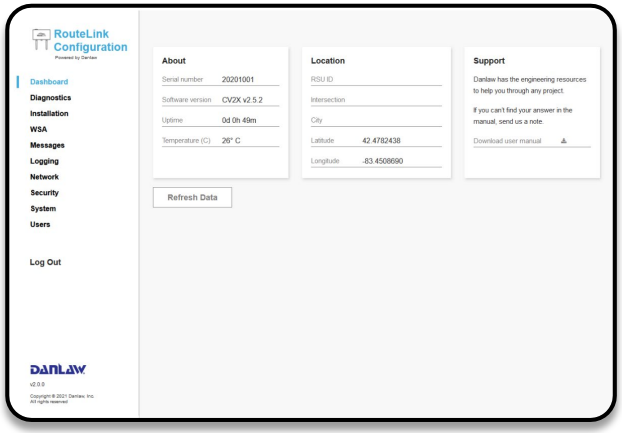






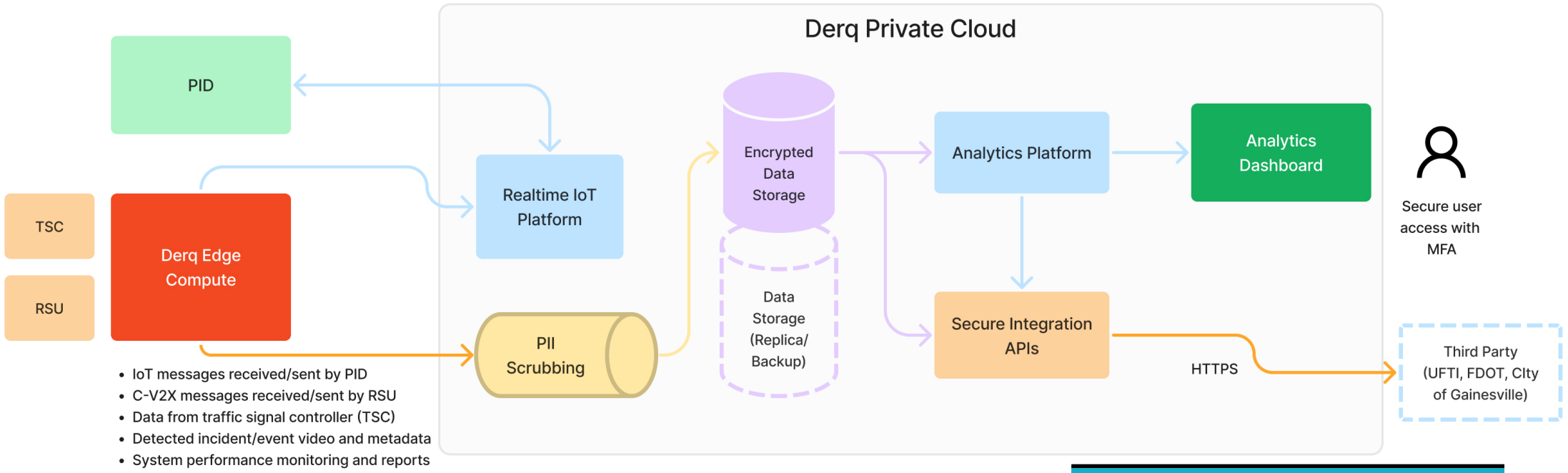


RouteLink Configuration Tool



AutoLink Configuration Tool

DATA WAREHOUSE ARCHITECTURE



Key Features:

- **Single interface** for all data visualization, in-depth analysis and system monitoring
- **Encrypted** data **storage** in private network
- **Robust architecture** designed for **high availability** and **disaster recovery**
- **Secure** user access management with **MFA**

Requirements	
Log all CV data sent/received	✓
User Friendly Interface	✓
Secure Third-Party APIs	✓
Encrypted storage	✓
PII Scrubbing	✓
System monitoring	✓

EQUIPMENT CERTIFICATION

Certificates can be shared upon request

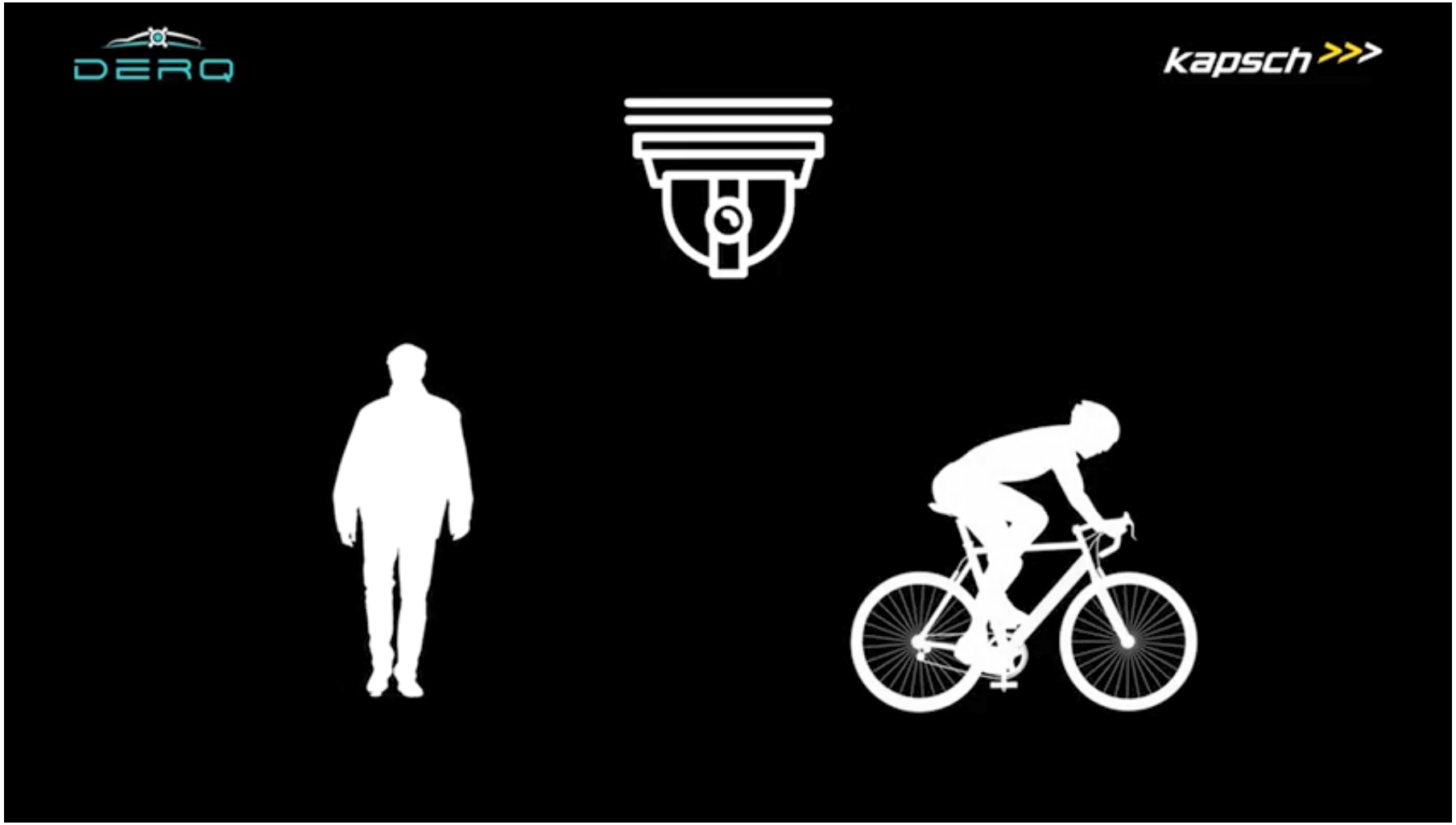
Device	Relevant Certifications
RSU	Tested and complies with proposed C-V2X waiver requirements (Docket 19-138) for FCC certification
Edge Unit	Certified to comply with CE, FCC, ANSI, MIL-STD-810G standards; Meets NEMA TS2 specs
Camera	Certified to comply with FCC, IEC, EN, UL standards; Meets NEMA TS2 specs
LTE Router	Certified to comply with FCC, IEC, EN, UL standards; Meets NEMA TS2 specs
Web-Managed Power Strip	Certified to comply with FCC, UL standards; Meets NEMA TS2 specs
SDLC Module	Meets NEMA TS2 specs
RRFB Assembly	FDOT Approved Product List
RRFB Controller	FDOT Approved Product List
Web I/O Controller	Certified to comply with FCC, IEC, EN standards

APPENDIX

SUPPORTING SLIDES

DERQ HAS INTEGRATED ITS PLATFORM WITH INDUSTRY LEADERS

Protecting pedestrians and cyclists at intersections



Red Light Violations and Prediction

Search by event ID

ROWS PER PAGE 25 PAGE 1 OF 30

Event ID	Event Type	Vehicle Speed	Date	Time	Time In Red	Direction	Video
615ae51a8503dd3376a6d718	RLV	44 mph	10/04/2021	07:27 AM	4.2	SB	
615ade0da1d9970dabeb0bdc	RLV	6 mph	10/04/2021	06:57 AM	5.8	NB	
6158a9e317fe9214b05569d9	RLV	22 mph	10/02/2021	02:50 PM	5.1	NB	
61588e2c17fe9214b05562b1	RLV	22 mph	10/02/2021	12:51 PM	8.9	SB	
61588e28f0b9e202425a9b04	RLV	19 mph	10/02/2021	12:51 PM	6.2	SB	
6157b81417fe9214b0552fe4	RLV	28 mph	10/01/2021	09:38 PM	4	SB	
6157b68417fe9214b0552f83	RLV	33 mph	10/01/2021	09:31 PM	4.5	NB	
61578740f0b9e202425a7c15	RLV	40 mph	10/01/2021	06:10 PM	4.2	NB	

Near Miss for Vulnerable Road User

Event ID	Event Type	Speed	Date	Time	Near Miss Type	PET(s)	TTC(s)	Gap Time(s)	Severity	Involved Road Users	Direction	Movement	Video
610eb7bf1a5de811def15847	NM-VRU	17 mph	08/07/2021	12:32	Right-of-way	0.7	N/A	N/A	N/A	Pedestrian, Passenger Vehicle	WB	TH	
60da1c155baab36a7e161674	NM-VRU	12 mph	06/28/2021	14:45	N/A	1.5	N/A	N/A	N/A	Pedestrian, Passenger Vehicle	SB	TH	
60d0de289d2d3c17b730ff2f	NM-VRU	36 mph	06/21/2021	14:18	N/A	1.7	N/A	N/A	N/A	Pedestrian, Passenger Vehicle	SB	TH	

Near Miss for Vehicle to Vehicle

Near Miss for Vehicle to Vehicle, WWD, RLV

PRODUCT DEMO – SAFETY INSIGHTS FOR NEAR MISS DETECTION

Using legacy detection cameras to detect and report near-miss incidents and hotspots

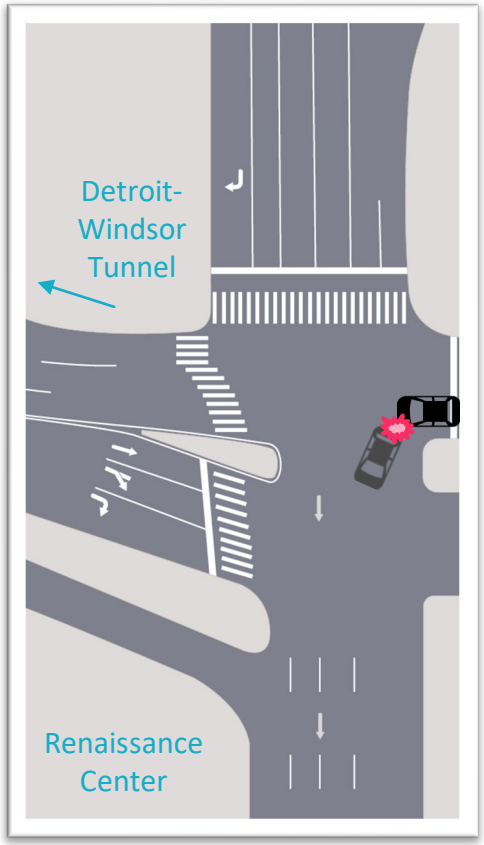
Individual Near-Miss Incident Report

Video URL: https://youtu.be/2KTKFbWHWnY

Near-Miss Heatmap

PRODUCT DEMO – Safety Analytics: Crash Recording

Crash detection & recording help operators and first responders take more effective actions



CRASH ALERTS CAN BE SENT IN REAL-TIME TO OPERATORS

62

PRODUCT DEMO – Safety INSIGHT: Crash Reconstruction

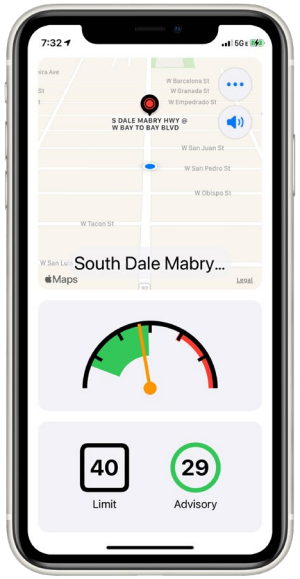
A unified view of the intersection can help determine the root cause of crashes

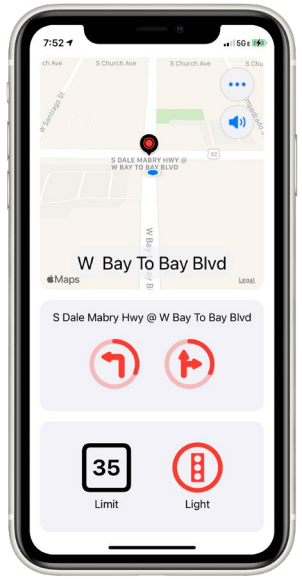
CRASH FORENSICS HELP OPERATORS UNDERSTAND ROOT CAUSES AND PLAN FOR FUTURE CHANGES

Video URL:https://youtu.be/JtR1IWUoII4

CēVē

- **Tampa-based software startup, focused on improving travel efficiency and safety through connected vehicle technologies**
- **Smartphone app and cloud service that connects drivers to transportation infrastructure**
  - Optimal speed advisories to avoid red lights, improving fuel efficiency and reducing vehicle emissions and wear
  - Time-to-green-light countdowns, reducing driver frustration and improving traffic flow
  - Red light warnings and speed limit notifications, improving safety





DERQ

DANLAW

- **30+ yrs experience testing and developing automotive electronics.** Largest supplier of aftermarket in-vehicle telematics products and services in US with over 6M devices deployed.
- Delivered **more than 8k V2X devices** across NA.
- **Leading RSU supplier:**
  - Ohio Department of Transportation
  - Georgia Department of Transportation
  - Michigan Department of Transportation
  - Macomb County Department of Roads
- **Leading OBU supplier:**
  - New York City Department of Transportation
  - Ann Arbor Connected Vehicle Test Environment (AACVTE)- UMTRI
- Installations including integration with school and transit buses, light and heavy-duty trucks, cars, snowplows and emergency vehicles.