Enabling Continuous Road Monitoring Applications using Connected Vehicle Data

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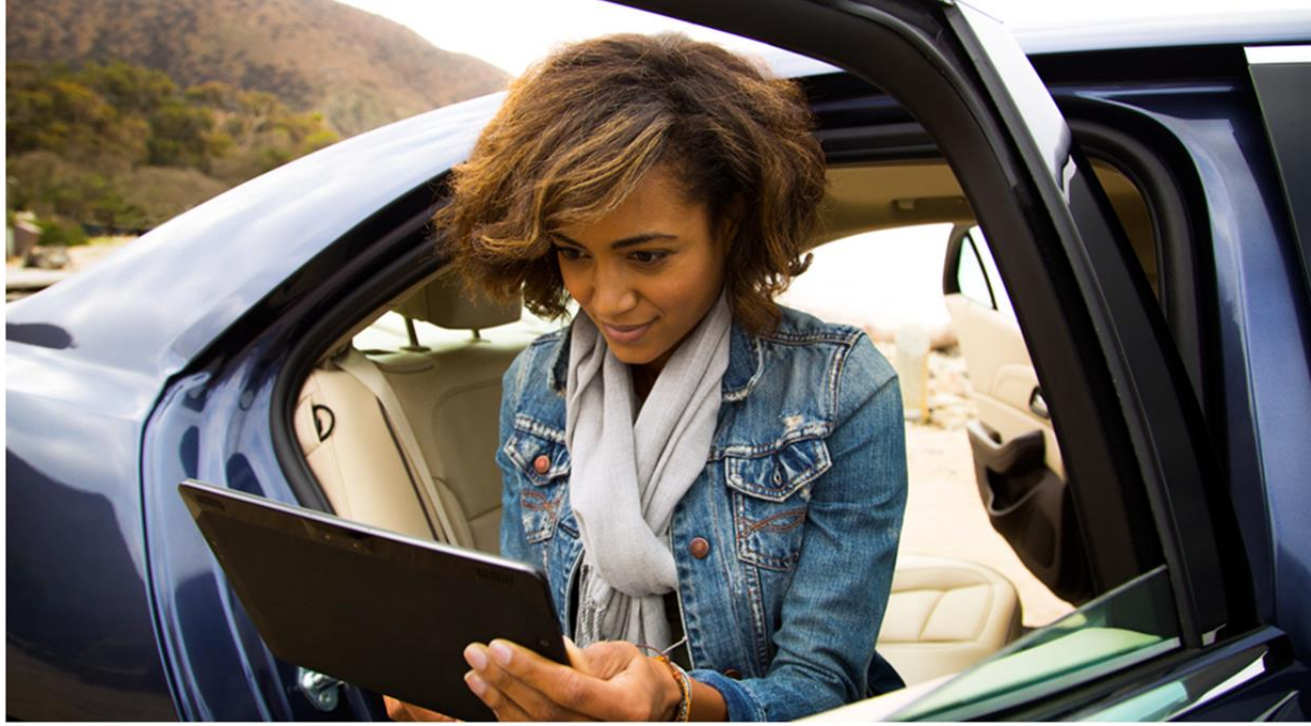
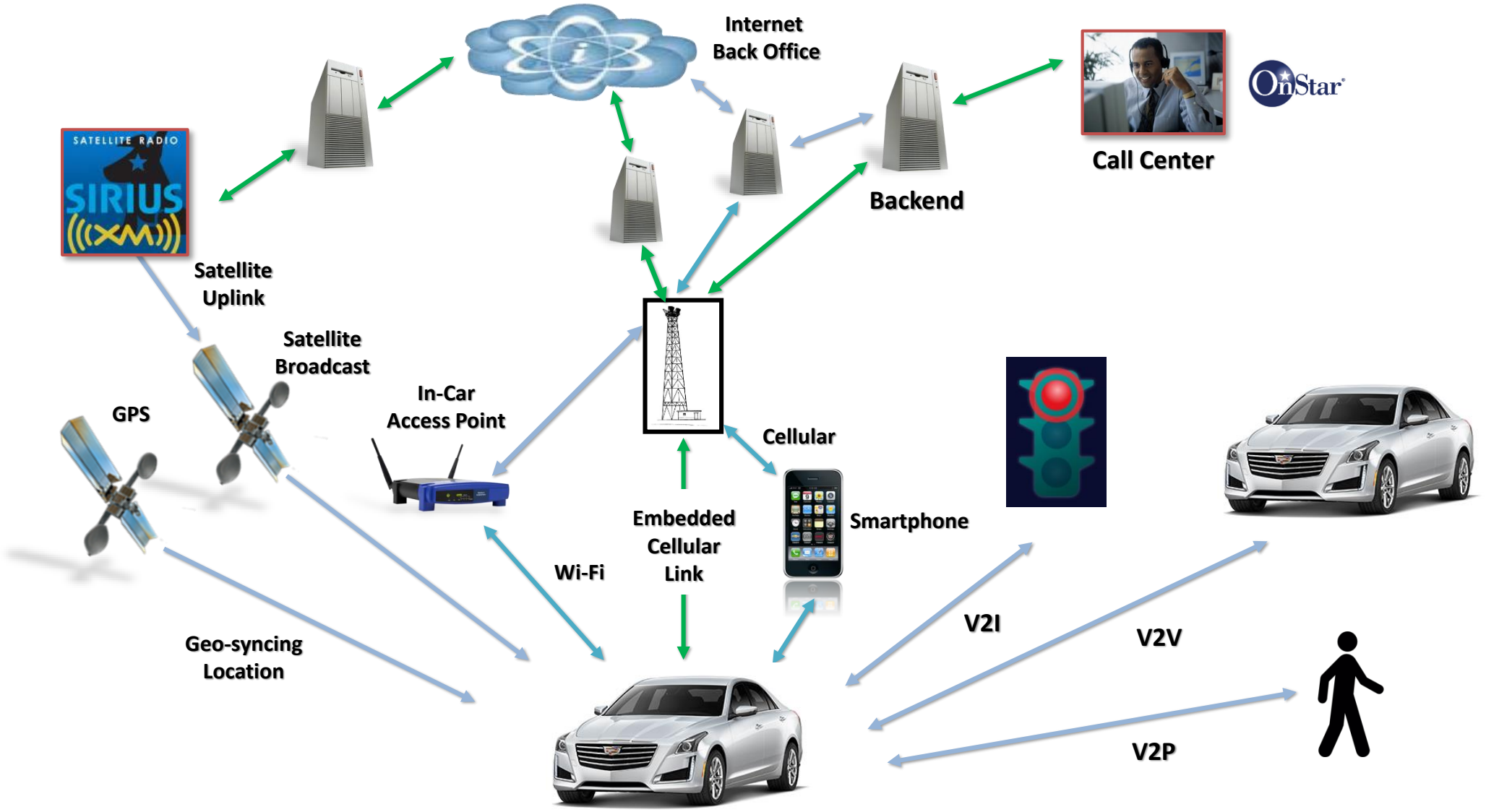
Pavement Evaluation 2019

What is a Connected Vehicle?



Connected Vehicle Ecosystem



Vehicle Electronics and Sensors

Rear-Passenger Flat-Panel Displays
Wheel Sensors
GPS Navigation
DVD Player
LED Lamp Cluster
Head-Up Displays
Dashboard-Instrument Cluster
Telematics System
Climate Control
Windshield Wipers
Radar Sensor
Transmission Control
Collision Avoidance
Adaptive Cruise Control
HID Headlamp
Memory Seat/Mirror/Steer
Airbag Control and Satellite Crash Sensors
Active Steering

Body Control
Suspension Control
Power Windows
Remote Keyless Entry
Seat Massage/HVAC
Adaptive Brake Lights
Parking Sensors
Rear-View Camera
Battery Management
Power Seats
Throttle Control
Engine Control Unit
Folding Door Mirrors
Eletrochromic Rear-View Mirrors
Car Radio
Antilock-Braking System/Electronic-Stability Program
Tire-Pressure-Monitoring System (TPMS)

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Vehicle Data and Crowd Sensing

Data is an asset that enables innovation in many areas of our business

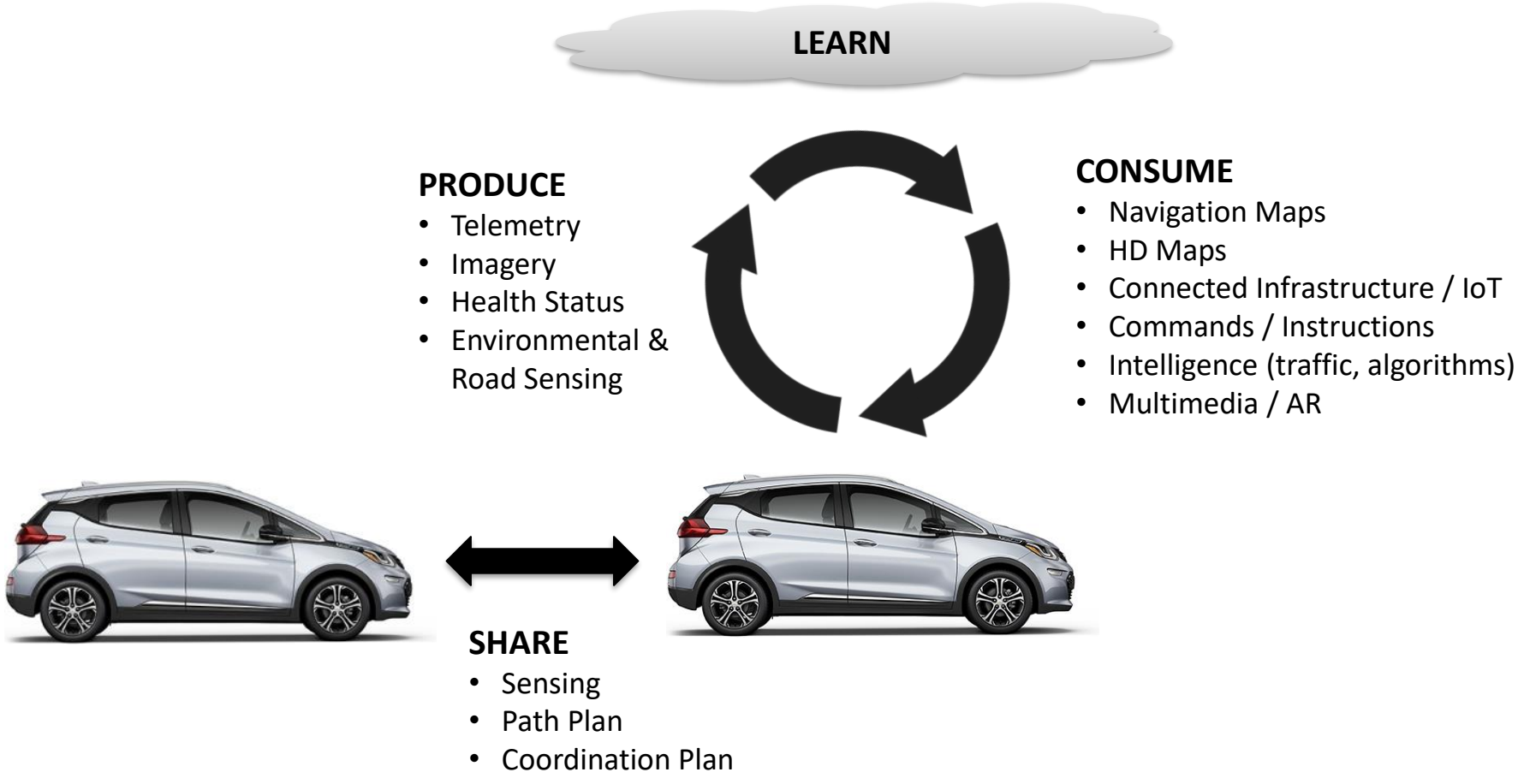
Crowd sensing is a paradigm where multiple vehicles sense the surrounding environment and communicate their perceptions to the cloud

Insights are created based on aggregated data

Enables customer features, system learnings and new business opportunities

Vehicles as Producers and Consumers of Data

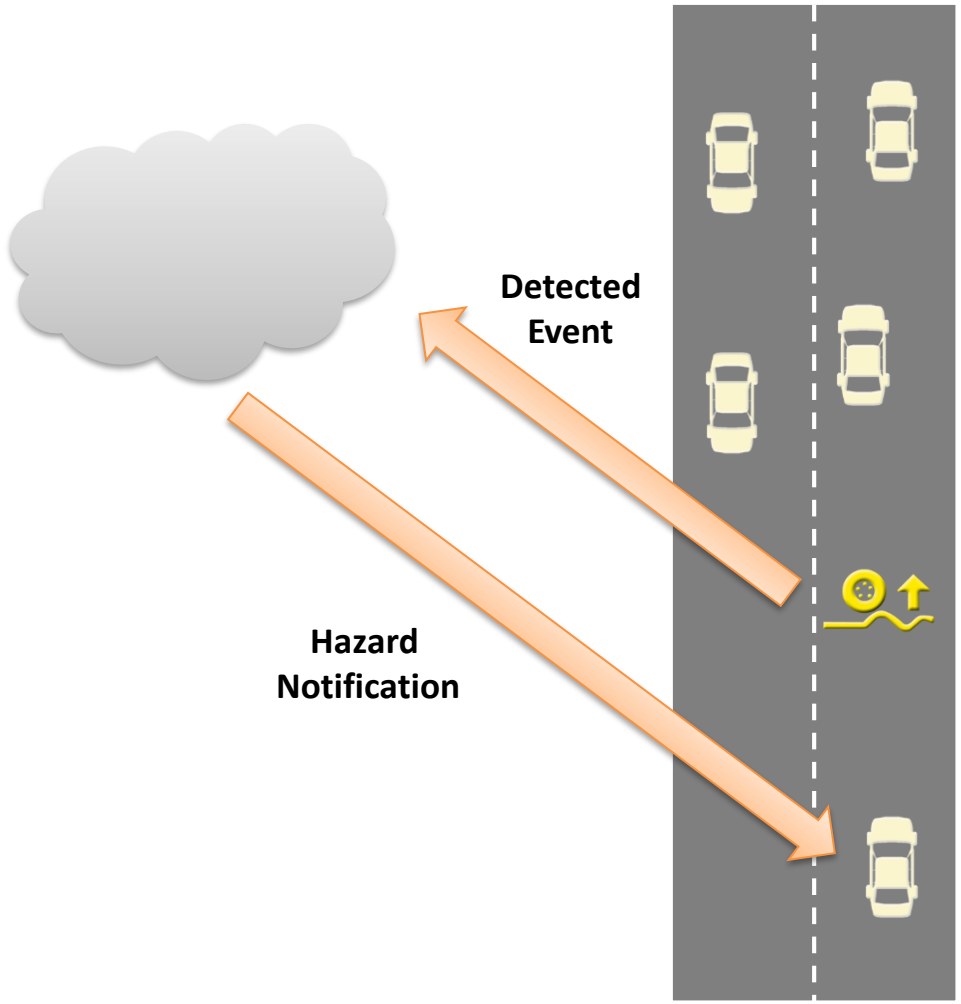
- Future vehicles will be substantial producers and consumers of data
- Learning model will increase environmental awareness and improve customer experience



Creating Roadway Insights from Vehicle Data

Sample Applications

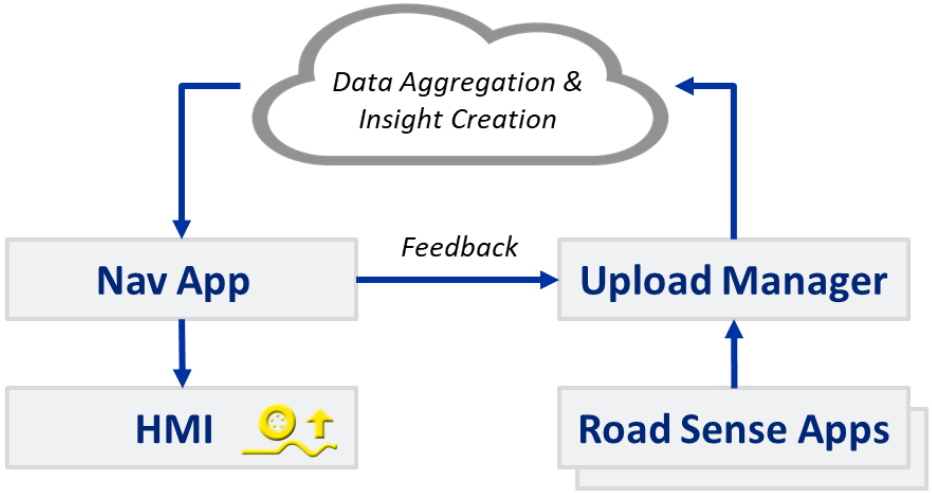
- Map
  - Speed limits
  - Stop Signs
- Traffic
  - Flow estimation
  - Hotspots
- Construction
  - Road closures
  - Lane closures
- Weather
  - Heavy rain
  - Snow
  - Fog
- Road Condition
  - Potholes
  - Roughness
  - Slippery Surface



Road Hazard Notifications

Value:

- Improves customer experience by increasing awareness of surrounding environment
- Road Sensing features monitor relevant vehicle data signals and makes a determination that a potential hazard may exist
- Information consensus performed in cloud to create high confidence insight

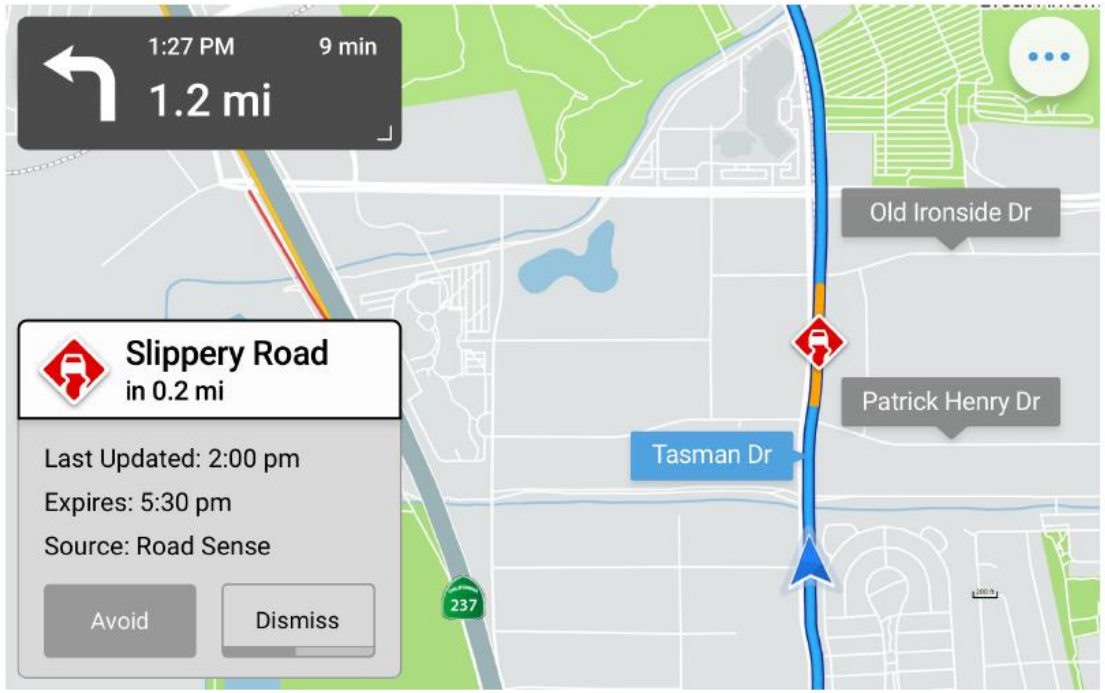


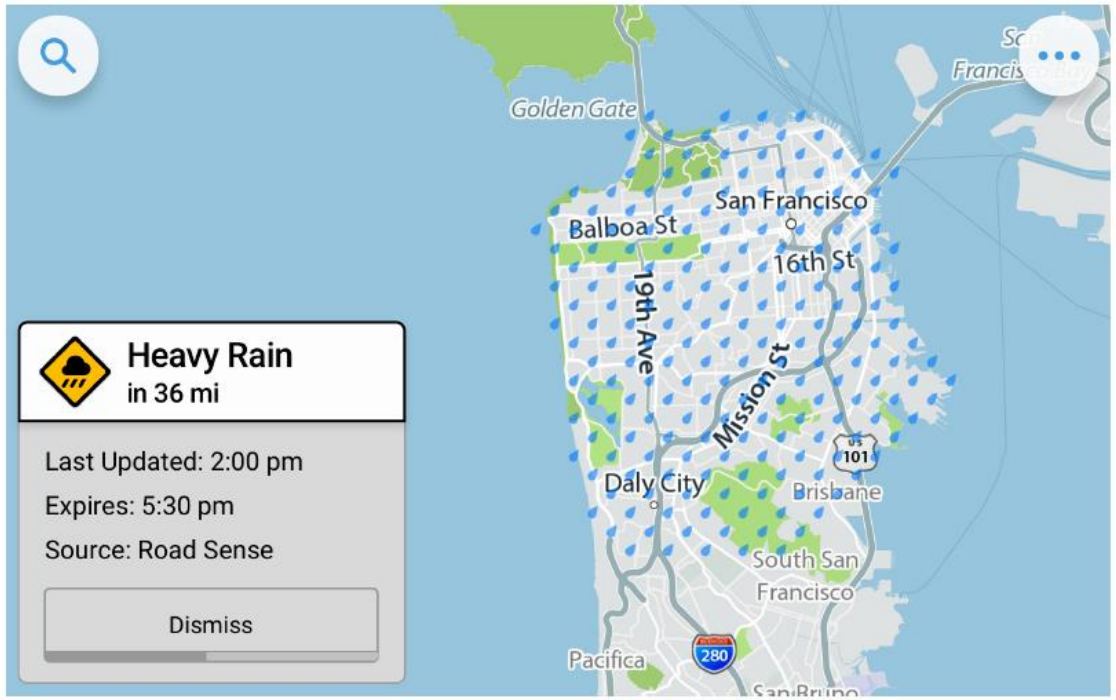
Use Case	Description	Example Inputs
Road Hazard	• Slippery road conditions • Potholes	• Traction control • Suspension sensor
Severe Weather	• Heavy Rain • Snow, Fog	• Wiper status • Temperature/humidity
Traffic Anomaly	• Roadway congestion • Backups at fork or exit locations • Accidents, construction, etc.	• Vehicle Speed • Posted Speed Limit • Traffic flow, Road Class

Road Hazard Notifications

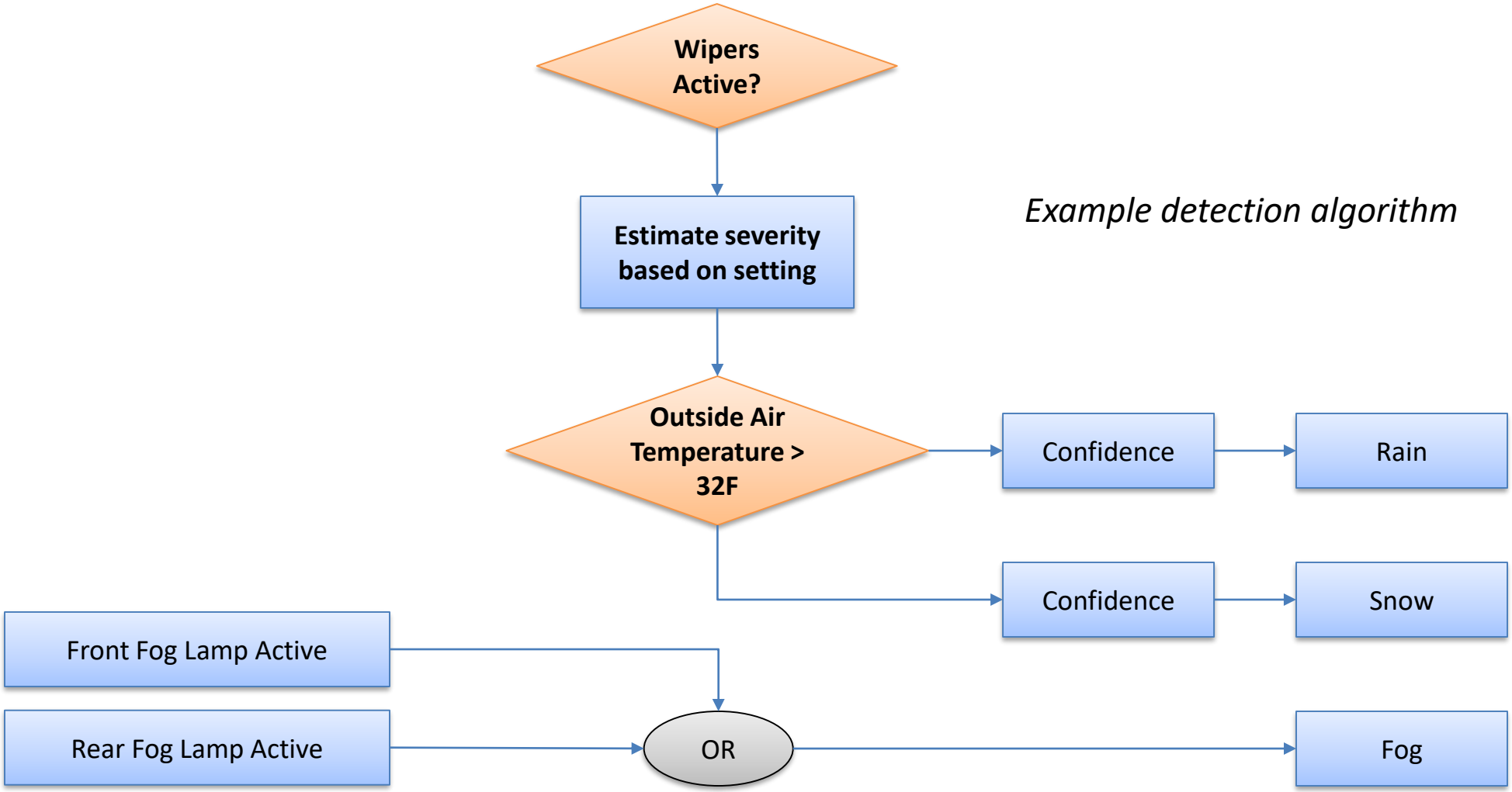
Experience:

- Customer is informed of relevant hazards in their path





Severe Weather Detection Logic

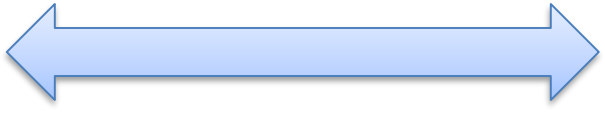


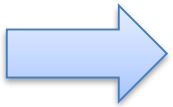
Example detection algorithm

Data Collection

Configuration, task development and data analytics

Device for feature development





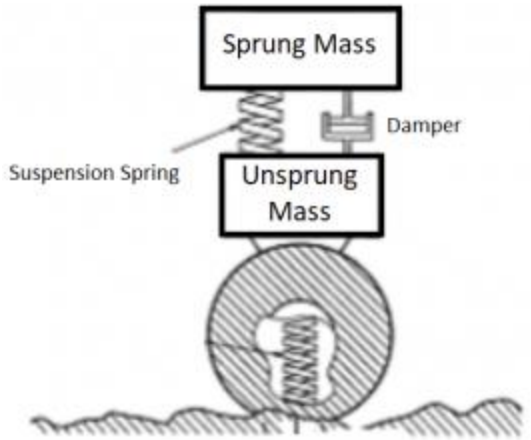
We deploy data collection tasks to connected vehicle fleet

Road Surface Detection using Wheel Speed Sensors

- Used by vehicles for speed indication, stability control and anti-lock braking system features
- Also used to support engine misfire diagnostics by monitoring engine speed oscillations
- Road surfaces may cause oscillating torque on the drive wheels which affects engine speed in a similar way as a true misfire
- An onboard algorithm differentiates true misfires from engine speed oscillations caused by the road surface
- There are two sources of road induced wheel speed oscillations:
  - Bumps such as potholes
  - Drive wheels slipping and hopping as if they are on slippery roads.

Road Surface Detection using Damping Systems

- Used in many luxury vehicles to improve ride comfort by modulating the suspension system in response to the sensed pavement conditions
- Magnetorheological fluid is employed inside shock absorbers to dampen rough road encounters by intelligently actuating the system using electric current
- The inputs to the system are the individual wheel displacement readings whose movements are referenced against the vehicle chassis
- By accumulating these displacement values over a specified distance, an estimated road roughness level can be determined.

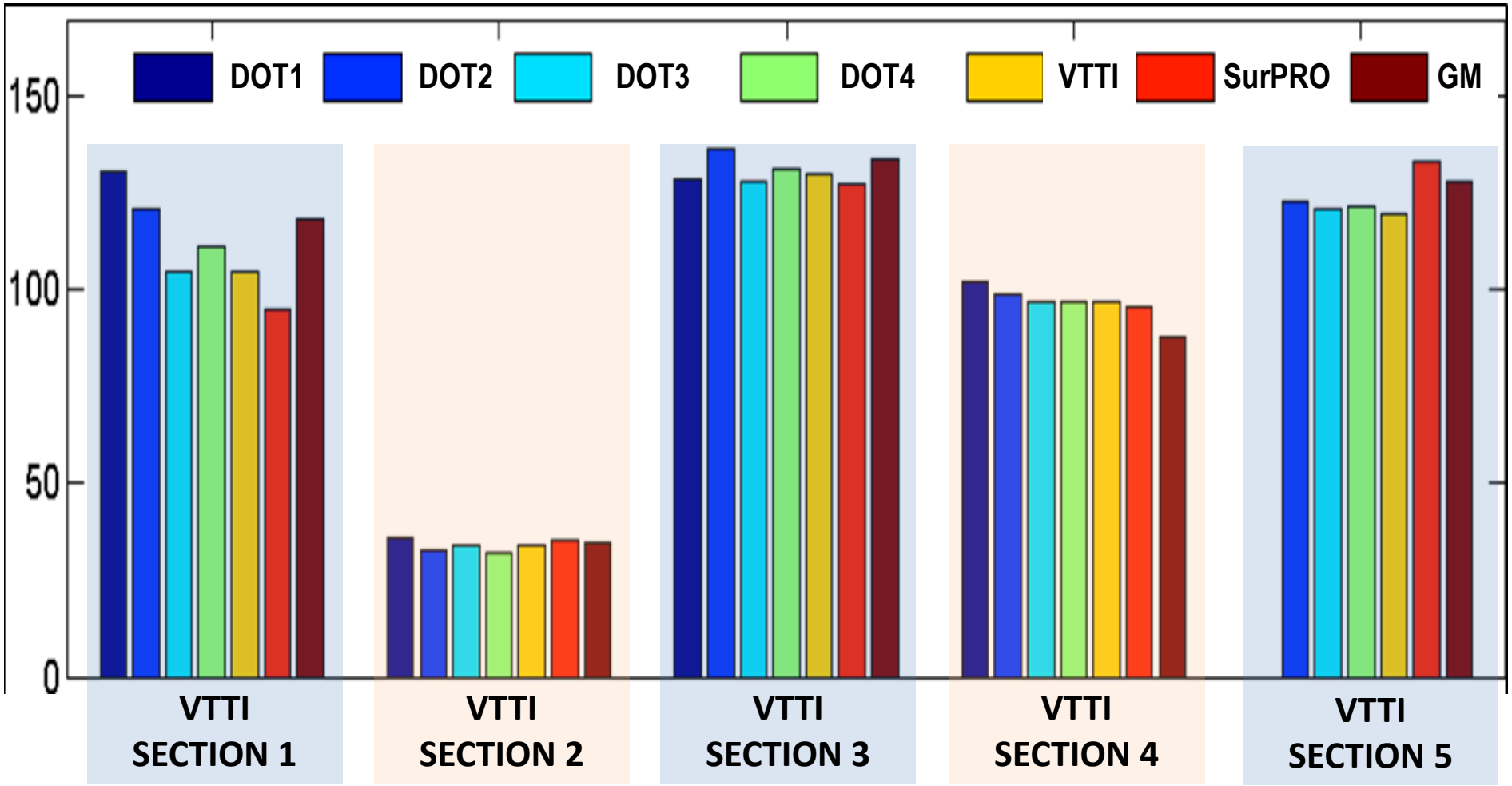


Road Surface Data

Data collection at VTTI Smart Road using single GM production vehicle

Each pavement section was driven 5 times at speeds of 20, 40 and 60 mph

Results were compared to 2017 Rodeo event and SURPRO reference profiler

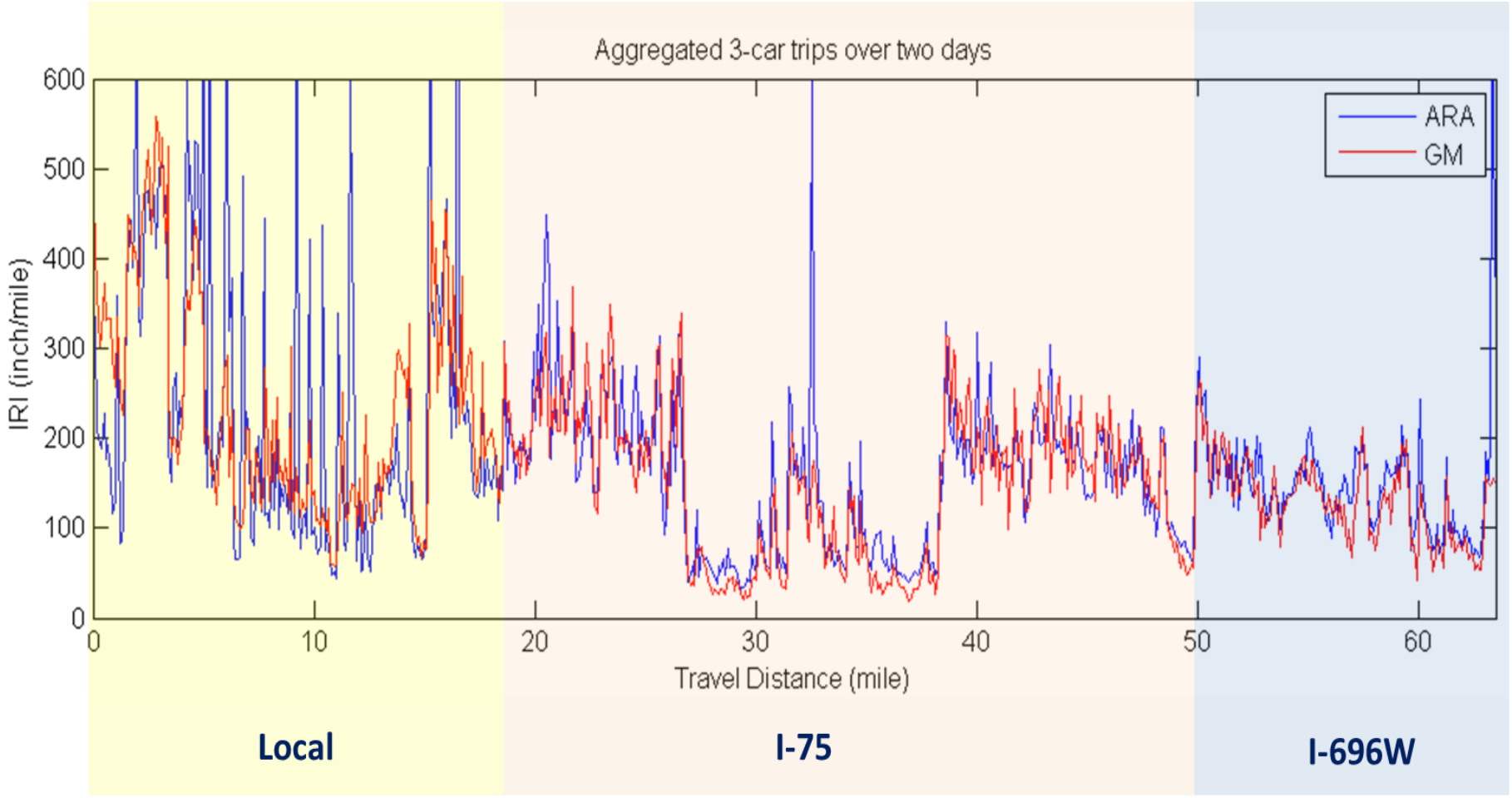


Road Surface Data

Joint data collection between ARA using their reference profilers and 3 of our production vehicles

The production vehicles followed the survey vehicle in the same lane

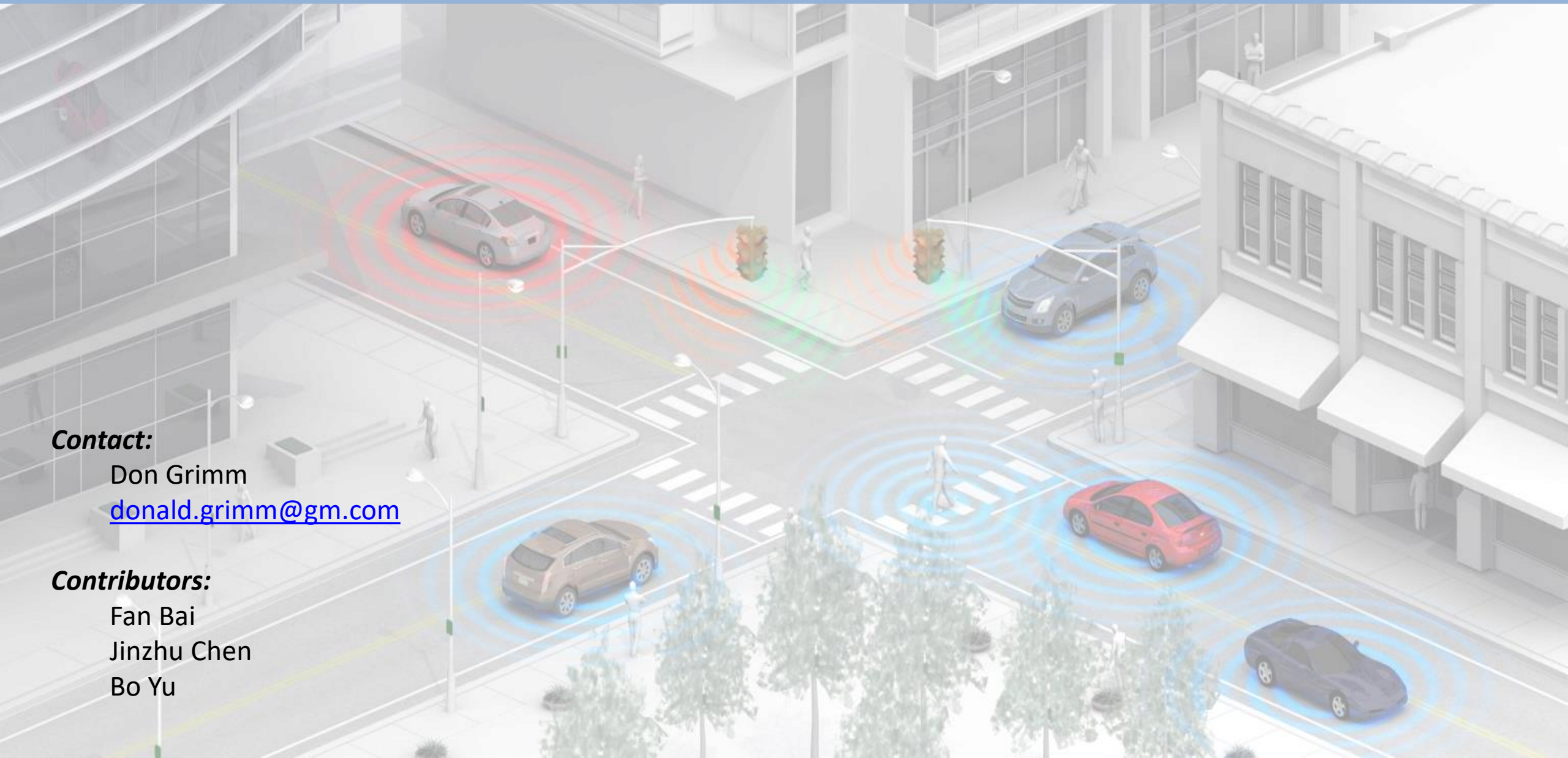
Data collection was performed at the speed limit for local roads and at a maximum of 60 mph on expressways



Summary

- Road safety and road condition are important to vehicle owners and pavement management professionals
- Connected vehicles enable the communication of numerous roadway characteristics to inform drivers about potentially hazardous conditions
- Underlying data that enables these features could also provide timely pavement condition data to improve the overall health of the road network

Thank You!



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