ITS washington

Edge AI for Real-Time Traffic Monitoring and Proactive Safety Management: TMC on the Road

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AIWAYSION

Projects

U.S. Department of Transportation Volpe Center

U.S. Department of Transportation Federal Highway Administration

- **"Edge Server-Based AI Application for Dilemma Zone and Traffic Conflict Events Detection"** (2022 – Present)
  - **F**unded by USDOT SBIR FY22 Phase I & FY23 Phase II projects
- **"Edge Computing and Sensor Fusion System for Comprehensive Monitoring of Traffic and Road Conditions"** (2023 – Present)
  - Funded by USDOT SBIR FY23 Phase I & FY24 Phase II projects
- **"Improve Roadway and Intersection Safety for Tribal and Rural Communities using Cost-Effective Sensing and Communication Technologies"** (2024 – Present)
  - Funded by FY23 Strengthening Mobility and Revolutionizing Transportation (SMART) grant program
- **"Integrated Perception and Communication System for Cooperative Driving Automation"** (2024 – Present)
  - Funded by USDOT SBIR FY24 Phase I project
- **"Artificial Intelligence Approach to Generate and Analyze Complete Streets Data at Scale"** (2024 – Present)
  - Funded by USDOT SBIR FY24.2 Phase I project
- **USDOT Intersection Safety Challenge (2023 – Present)**

SBIR America's Seed Fund

SMART

COMPLETE STREETS AI

Generating, Integrating, and Activating Data for Mobility

INTERSECTION SAFETY CHALLENGE

Partners & Customers

Transportation agencies (local, state, federal, tribal nation), universities, technology companies

Award-Winning Edge AI Technology

Mobile Unit for Sensing Traffic (MUST)

Perception & Computing & Communication All-In-One Unit

Roadside Edge AI Platform for Real-Time Decision Making

Plug-and-Play Solution for Both Urban & Rural Areas

SPECIFICATIONS

Operation Temperature	-40 ℃ ~ 70 ℃
Operation Relative Humidity	10% ~ 90%
Ingress Protection	IP 65
Power Supply	12V(DC)
Energy Consumption	< 35Watts
CPU	ARM1176JZF-S 700 MHz
GPU	128-Core Maxwell 1600MHz
Communication	3G/4G/5G, Ethernet
Operation System	Linux
Local Data Storage	Micro Secure Digital (SD) Card
Weight	10 pounds
Dimensions	170 mm (length), 170 mm, (width), 300 mm (height)

Toppenish, Yakama

Bellevue, WA

Tucson, AZ

Spokane, WA

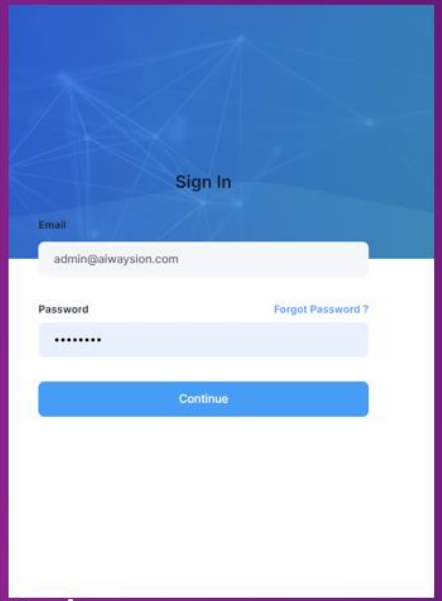
Tacoma, WA

Olympia, WA

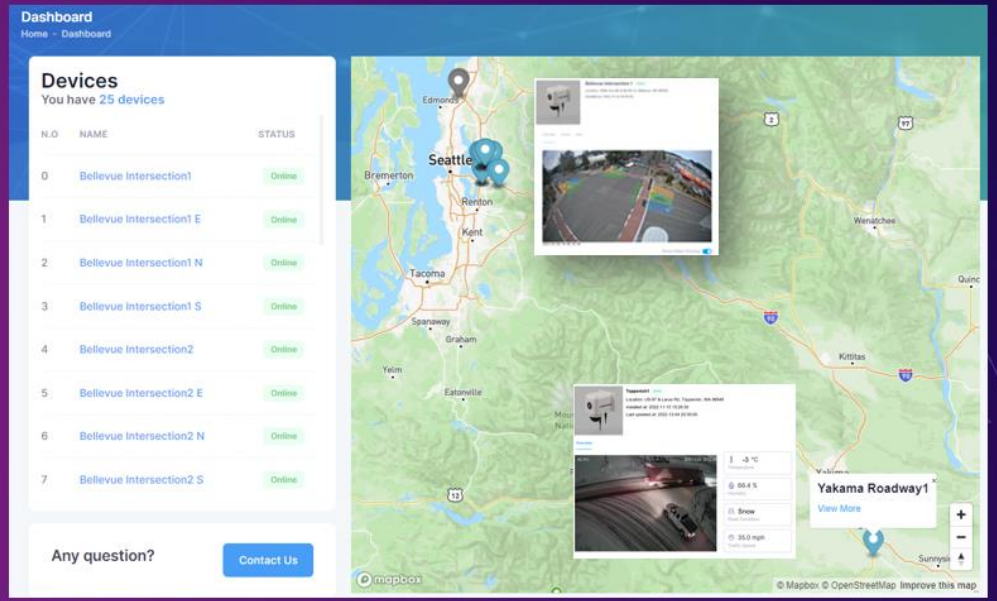
Lynnwood, WA

WaysionNet (Virtual TMC & Copilot)

Device & data management, analysis, visualization & control



Login

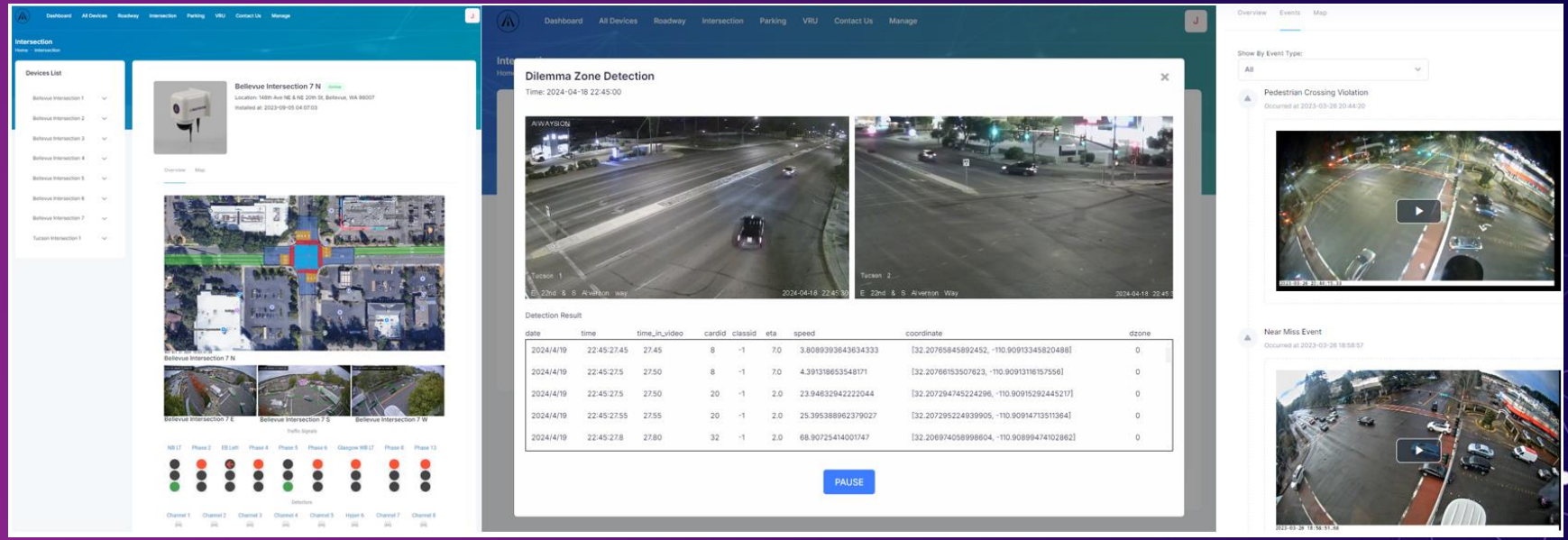


Device list & map

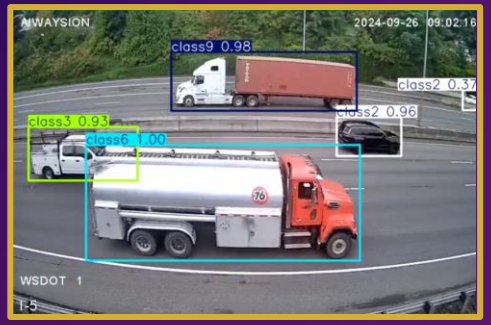
Mobile APP

WaysionNet (Virtual TMC & Copilot)

Device & data management, analysis, visualization & control



AI-Powered Solutions



01 Traffic Data Collection

Vehicle volume, speed, classification, travel time measurement, etc.

02 Pedestrian Data Collection

Counting and classification (pedestrian, cyclist, scooter, wheelchair, etc.)

03 Environment Conditions /Weather Station

- Environmental conditions (i.e., temperature, humidity, air quality)
- Road surface conditions (i.e., dry, wet, ice, snow)
- Visibility conditions

04 Safety Applications

- Collision and near-miss events
- Hazadous conditions (low visiblity, snow and ice covered road surface, etc.)
- Dilemma zone
- Stopped vehicle
- Wrong way driving
- Speeding

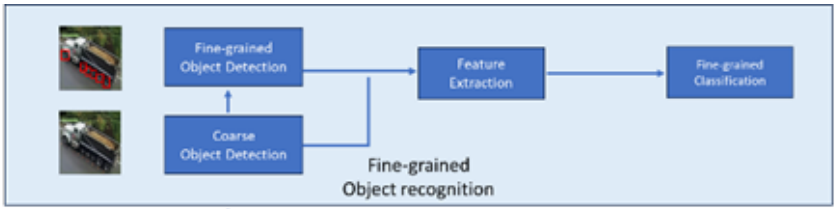
05 Connected & Autonomous Vehicles

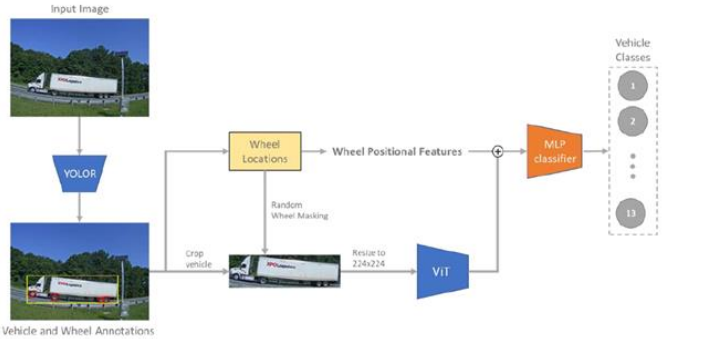
- Vehicle-to-Infrastructure (V2I) communication
- Pedestrian-to-Infrastructure (P2I) communication

06 Parking & Curb Management

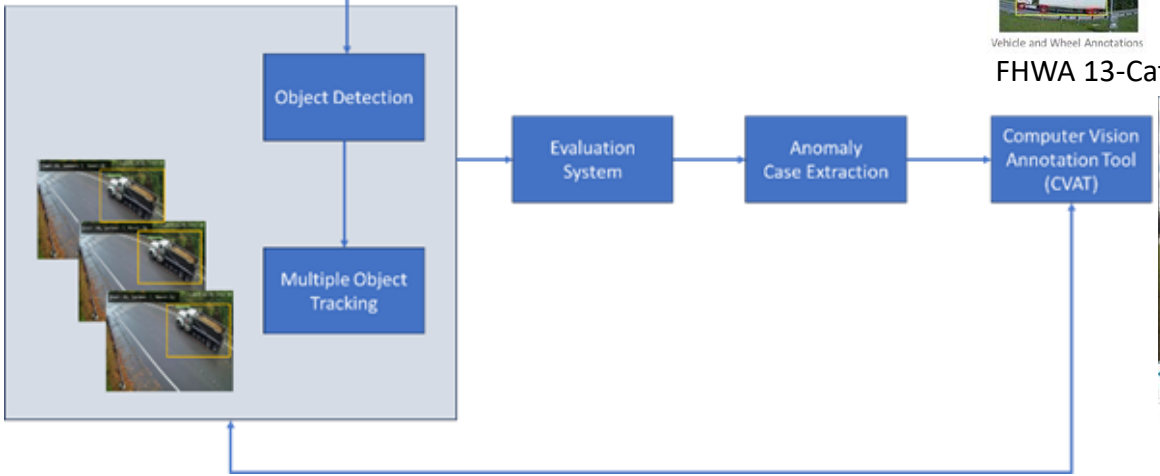
- Parking events (i.e., vehicle type, location, duration, ingress/egress time)
- Availability & occupancy

Object Detection & Classification





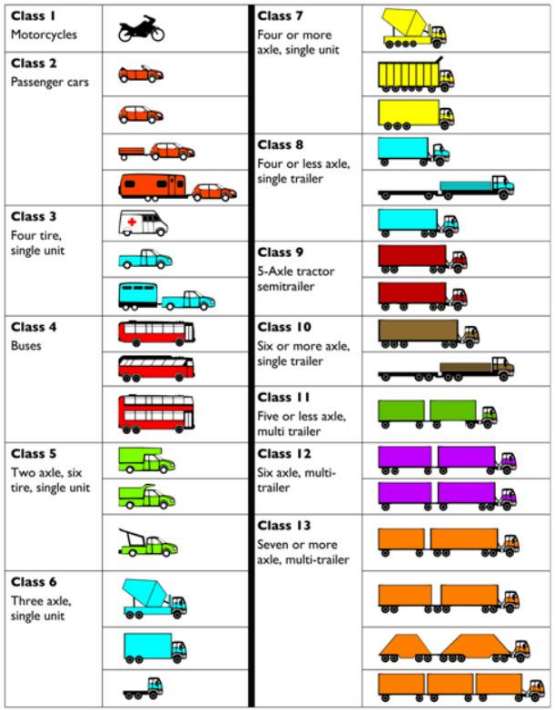
FHWA 13-Category Classification



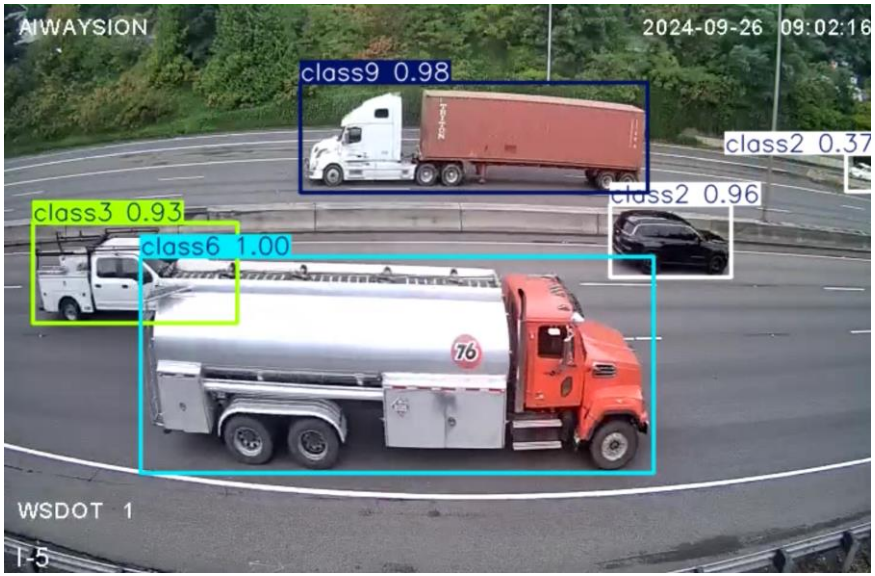
Computer Vision Annotation Tool (CVAT)

AutoML system for object detection & classification algorithm development

Vehicle Classification: 13 Classes

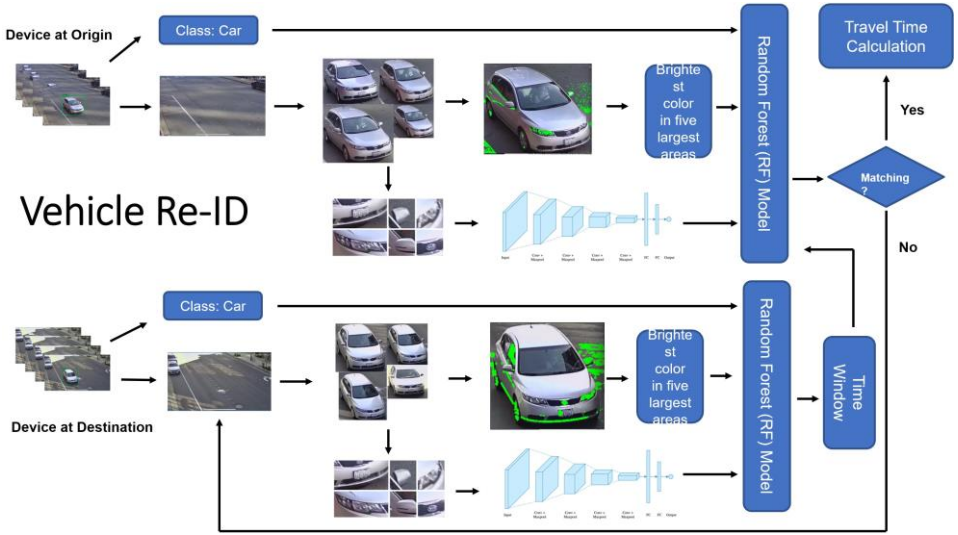


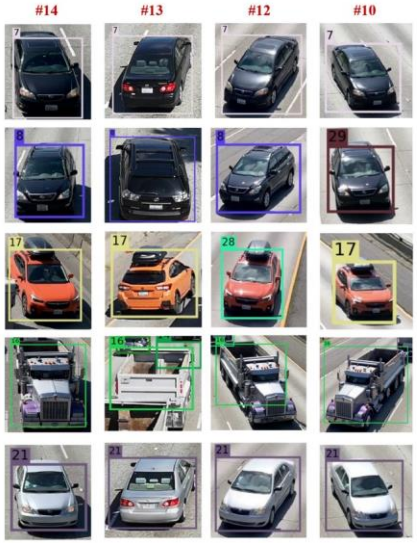
Vehicle Classification: 13 Classes

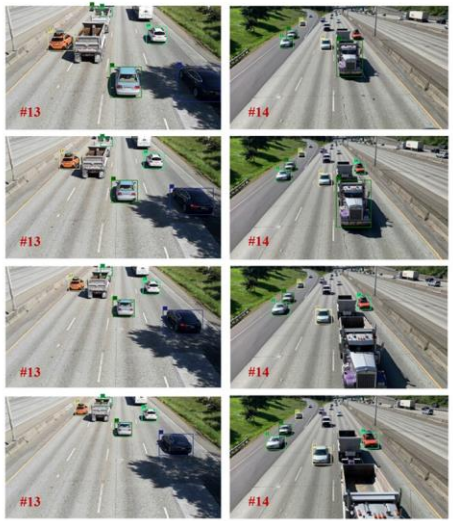


Vehicle Re-ID

Video-based vehicle re-ID for travel time estimation





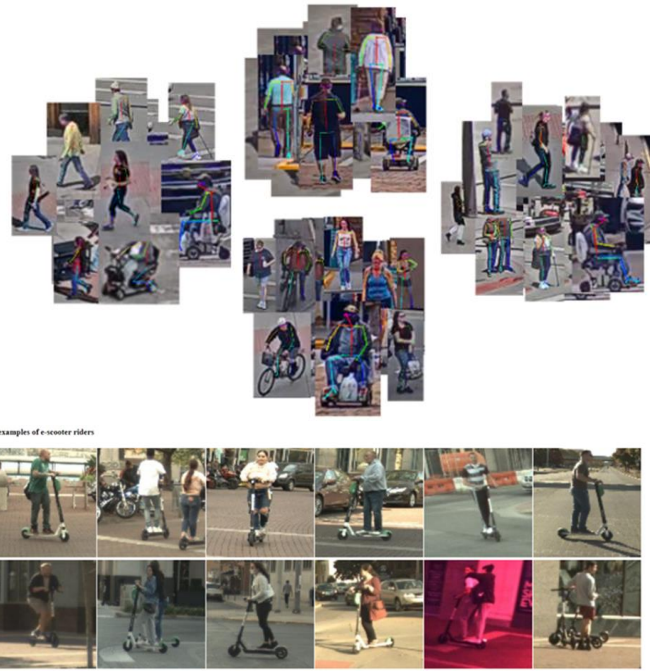


Micromobility Data Collection

- Data collection following the Traffic Monitoring Guide (TMG) formats

Type of Count (Column 20) – Required

- E = electric devices (e.g., electric bicycles, Segway®, electric scooters, etc.)
- 1 = pedestrians (only)
- 2 = bicycles (only)
- 3 = equestrians (only), “persons riding a horse or other animal”
- 4 = persons using wheelchairs (including powered wheelchairs)
- 5 = persons using other mobility devices (skates, skateboards, etc.)
- 6 = motorized vehicles on a trail (e.g., snowmobiles, all-terrain vehicles, etc., specify in Field 32, Other
- Notes); implies Facility Type “0”
- 7 = all electric devices, bicycles, and pedestrians (sum of codes E, 1, and 2)
- 8 = all micromobility traffic on the facility (sum of codes E and 1 through 5)
- 9 = all traffic on a trail (sum of codes E and 1 through 6)
- 0 = other animals (e.g., pack mules, deer, or migrating wildlife; specify in Field 32, Other Notes)

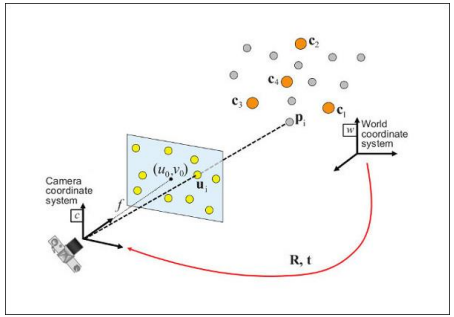


Micromobility Data Collection

Classes	Name	Classification Results/ Detected Images
1	Pedestrian	
2	Pedestrian Using Wheelchair	
3	Pedestrian Using Bicycle	
4	Pedestrian Using Non-Motorized Device/Prop Other	
5	Pedestrian Using Scooter or Skateboard	

Auto Camera Calibration

Camera coordinates to real-world coordinates (2D-3D transformation)



$$s\,p_c = K\,[\,R\,|\,T\,]\,p_w$$

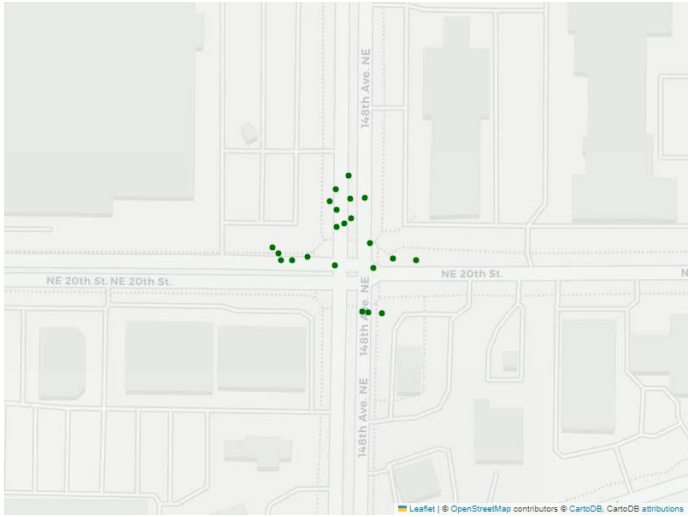
$$s\begin{bmatrix} u \\ v \\ 1 \end{bmatrix} = \begin{bmatrix} f_x & \gamma & u_0 \\ 0 & f_y & v_0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} r_{11} & r_{12} & r_{13} & t_1 \\ r_{21} & r_{22} & r_{23} & t_2 \\ r_{31} & r_{32} & r_{33} & t_3 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

Camera view 1

Camera view 2

Camera view 3

Real-Time Multi-Camera Multi-Object Tracking and Trajectory analysis



Real-world coordinates & trajectories of vehicles & ped/cyclists from different camera views

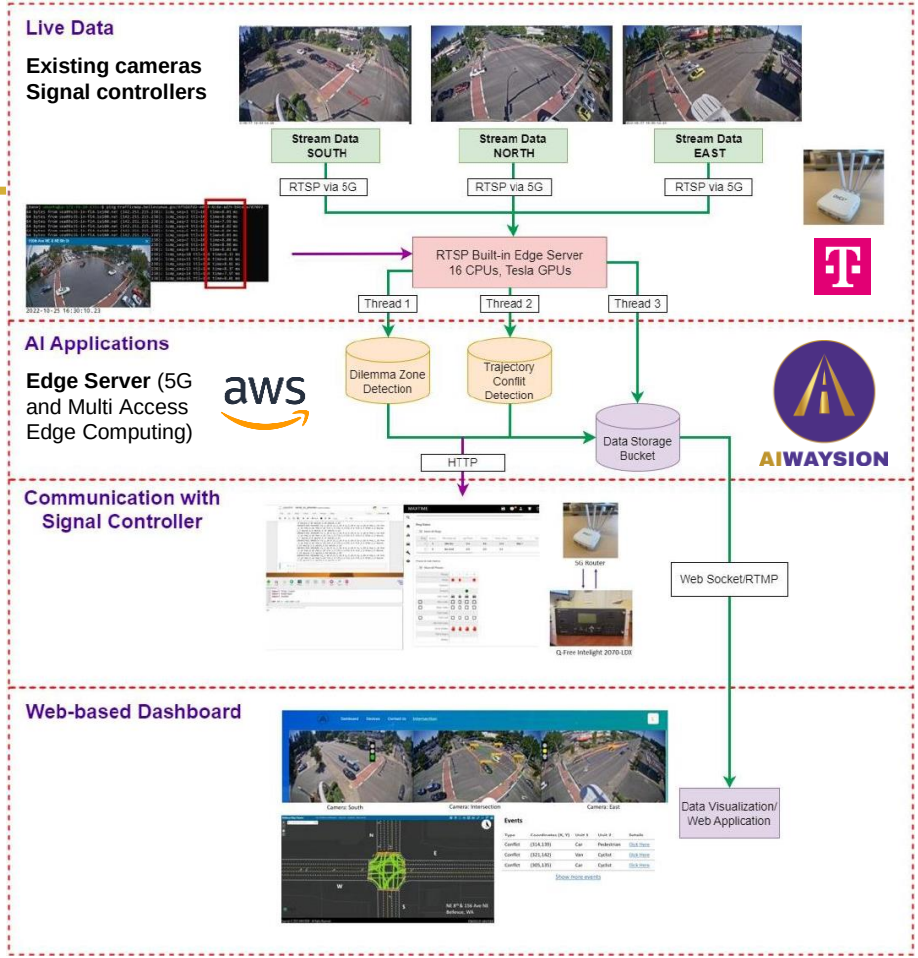
Camera view 1

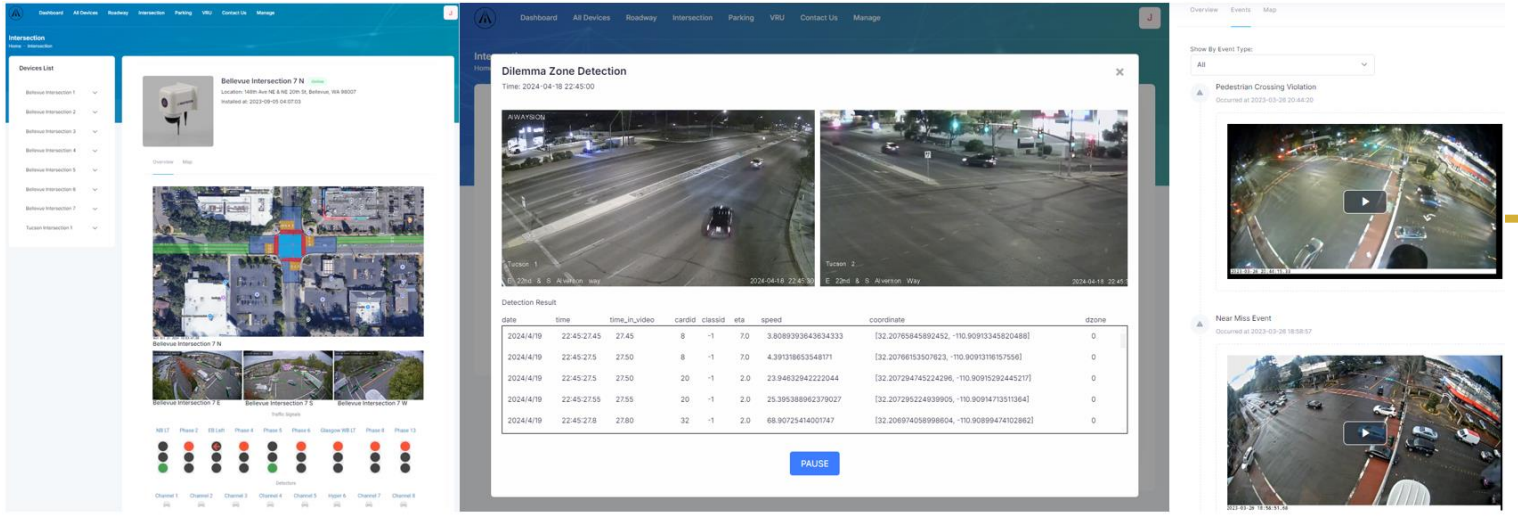
Camera view 2

Camera view 3

Intersection Safety

- Leveraging existing cameras, MUSTs, 5G & Edge Server (MEC)
- Deep learning algorithms for advanced detection, classification, tracking, and prediction of road users
- Performing real-time video analytics applications
  - Dynamic dilemma zone monitoring & protection
  - Trajectory conflict events (collision/near-miss) detection & warning
- Performance metrics
  - **Latency (<100 ms)**
  - **Accuracy (90+%)**





Real-time monitoring and safety interventions

Dilemma Zone Events Detection

Collision/Near-Miss Events

Lack of Data & ITS in Rural Roads

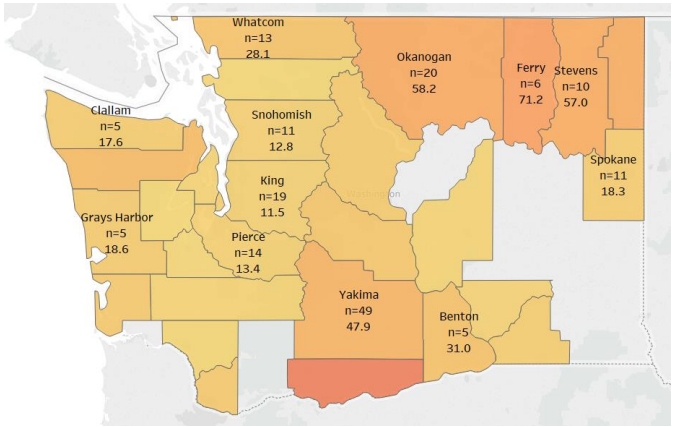
- Lack of funding and infrastructure support for deploying conventional data collection equipment
  - Limited internet connection
  - Low-volume rural roads
- Lack the technical personnel and technologies
  - To manage, visualize, and analyze the data collected
- Specific data collection needs
  - For example, semi-trucks & agricultural vehicles, heavy fog/low visibility, animals, wildfires, etc.
- Tribal sovereignty and privacy over the data collected
  - Data processing within the device, protecting the privacy of communities
  - Data owned by tribe, and tribe should have control over how the data is used, shared, and stored.

Yakama Nation

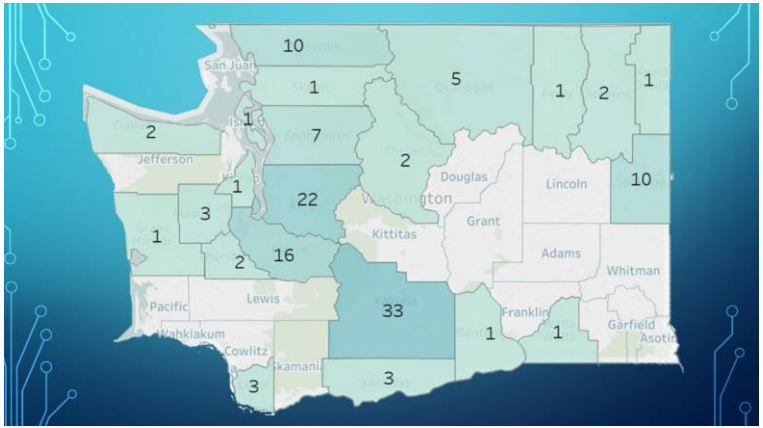
- Federally recognized tribe
- Over one million acres
- 1,200 miles of public roads, most are in rural areas

Prevailing Safety Issues

Yakima County has the **highest rates of motor vehicle and pedestrian fatalities** for Native American and Alaskan Native (NA/AN) Populations in Washington



AI/AN Motor Vehicle Fatality Counts and Rates per 100,000 Population by County of Residence, 2011-2016. (Source: Washington State death certificates linked to the Northwest Tribal Registry to identify AI/AN race)



Count of AI/AN pedestrians killed by motor vehicles by residential county of descendent. Yakima County: 33 in Yakima County as opposed to 91 total in Washington State. (Data source: Washington State death certificates linked to the NW Tribal Registry, 1999-2016.)

US 97 Corridor Safety Issues

US 97 – Toppenish to Union Gap – Corridor

- A history of severe and fatal collisions
- Over the last 10 years: 350 serious injury crashes and 22 fatal crashes

US 97 CRASH HISTORY

2001 - 2021

	Lateral A	2nd Avenue	Jones Road	W. Wapato Road	S. Wapato Road	McDonald Becker	Buster	Fort Road	SR 22	Larue Road	SR 22 SR 223
Fatalities	1	1	3	3	2	2	1	2	2	7	0
Injuries	55	20	35	78	22	56	21	73	38	26	11
Collisions	89	36	52	163	58	59	29	113	101	33	24

FHWA Build A Better Mousetrap Award

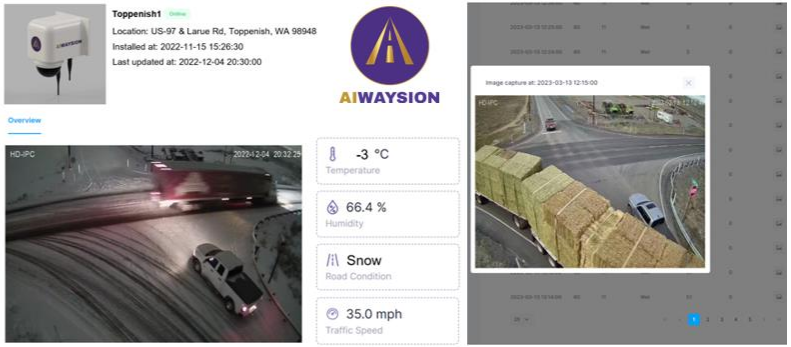
- **2023 Innovative Project Award**
- **2023 Best All Around Award**

Build a Better MOUSETRAP
National Recognition Program for Transportation Innovation

U.S. Department of Transportation
Federal Highway Administration

Improve Roadway and Intersection Safety Using Cost-Effective Sensing and Communication Technologies

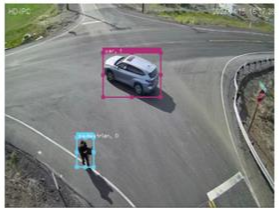
Edge AI Device for Traffic & Road Conditions Monitoring and Hazardous Events Detection



Road Safety Information System

Trucks & Tractors

Road Conditions



Pedestrian Safety

Private 5G Communication

VMS Sign

AIWAYSION

WSDOT

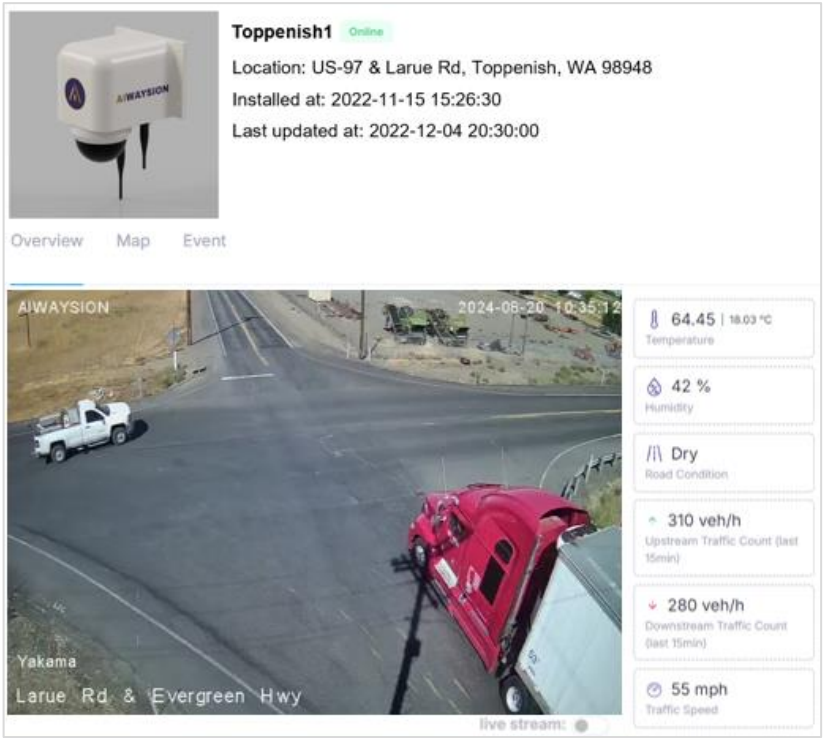
US 97 Corridor Safety Improvement

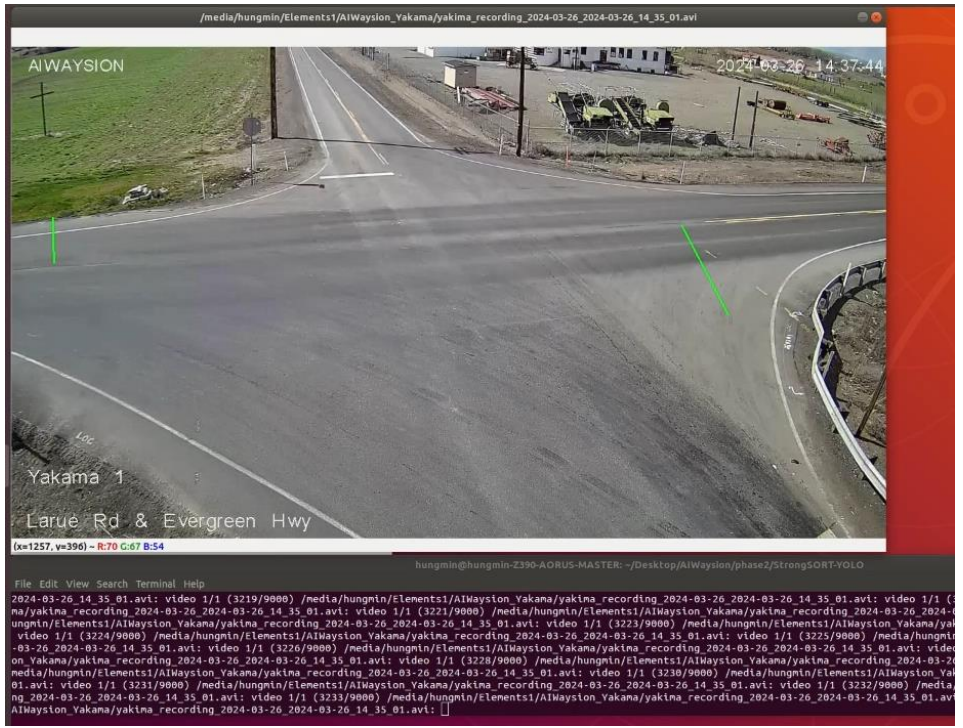
- **Monitor** traffic, vulnerable road users (pedestrian, cyclists), roadway surface conditions (e.g., snow, ice, wet, and dry), environmental conditions (temperature and humidity), visibility conditions, etc.
- **Detect hazardous events** such as stopped vehicles, speeding, heavy fog/low visibility, adverse roadway surface conditions, collision, etc.
- **Communicate** with TMC or traffic control devices (e.g., variable message signs) for real-time countermeasures.

Mobile Unit for Sensing Traffic (MUST)

Traffic and Road Conditions Monitoring

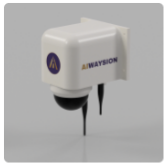
Web dashboard: real-time data collection & visualization





Data Collection & Management

Web dashboard



yakama01 Online

Location: US-97 & Larue Rd, Toppenish, WA

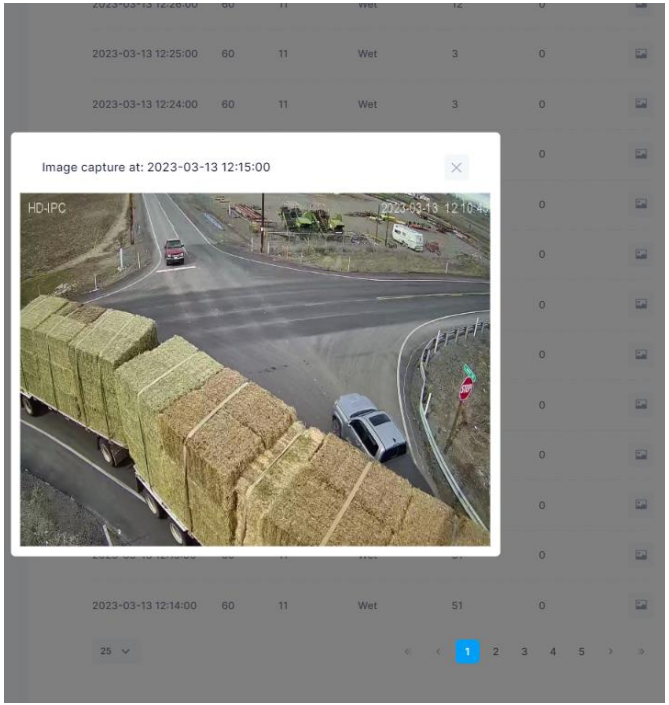
Installed at: 2023-01-05 03:46:04

Last updated at: 2023-03-13 13:04:36

Overview | History | Analytics | Map | Event

03/13/2023

DATE	HUMIDITY	TEMPERATURE	ROAD CONDITION	TRAFFIC COUNT	TRAFFIC SPEED	IMAGE
2023-03-13 12:58:00	58	12	Wet	12	0	
2023-03-13 12:57:00	58	12	Wet	12	0	
2023-03-13 12:56:00	58	12	Wet	36	0	
2023-03-13 12:55:00	58	12	Wet	36	0	
2023-03-13 12:54:00	58	12	Wet	36	0	
2023-03-13 12:53:00	58	12	Wet	3	0	
2023-03-13 12:52:00	58	12	Wet	3	0	



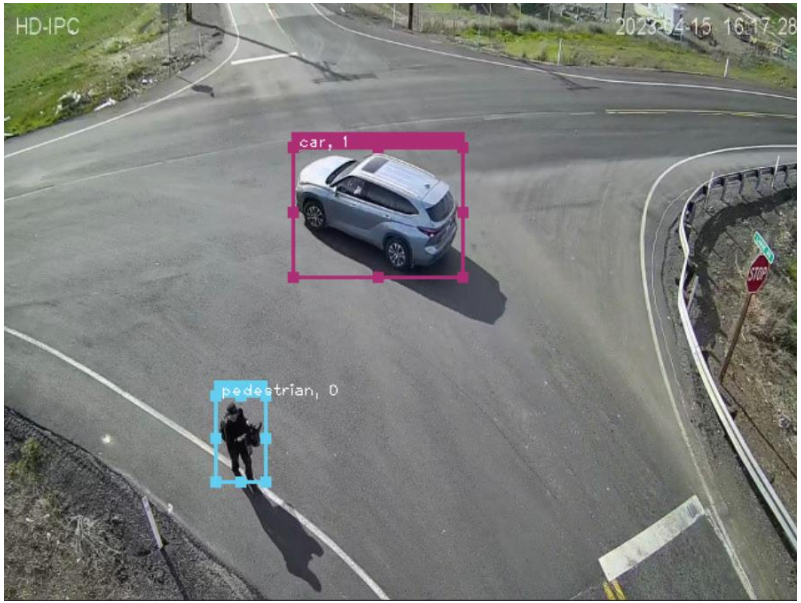
Real-Time Safety Insights

- Movements of semi-trucks, agricultural vehicles
- Interactions (collision/near-miss events)

Larue Rd and Highway 97, Toppenish, Yakama Nation

Real-Time Safety Insights

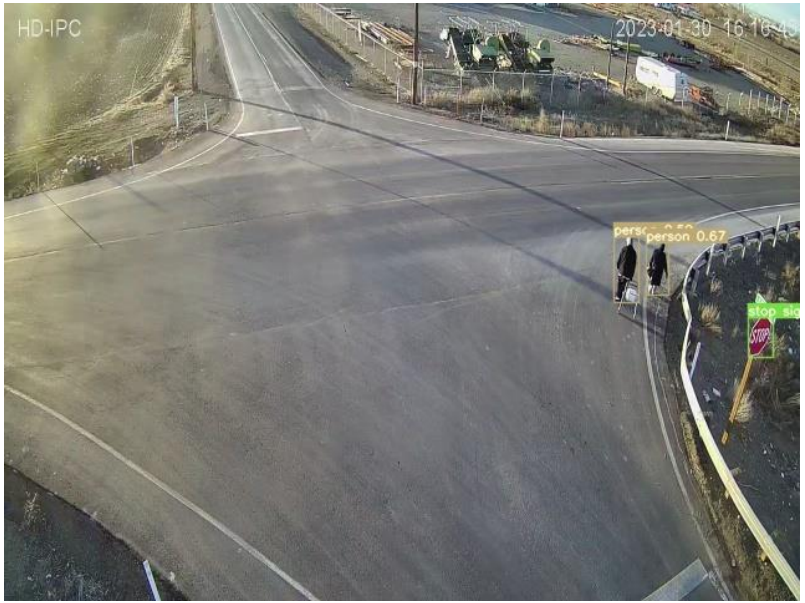
Pedestrian safety (Average about 30 pedestrians on a weekday at Larue Rd & US 97 intersection)



Larue Rd and Highway 97, Toppenish, Yakama Nation

Real-Time Safety Insights

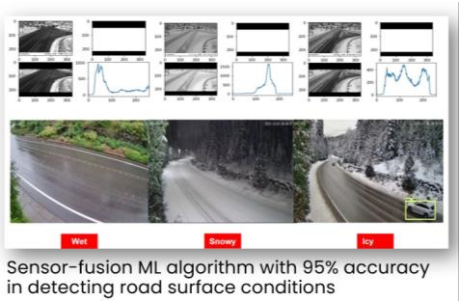
Average about 30 pedestrians on a weekday at Larue Rd & US 97 intersection



Larue Rd and Highway 97, Toppenish, Yakama Nation

Real-Time Safety Insights

Heavy fog/low visibility, road surface conditions, visibility/fog, wildfire

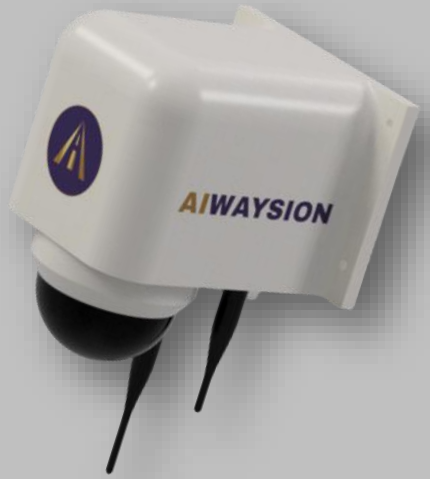


Sensor-fusion ML algorithm with 95% accuracy in detecting road surface conditions

Larue Rd and Highway 97, Toppenish, Yakama Nation

Real-Time Safety Insights

Pedestrian, nighttime/low visibility, adverse weather conditions



THANKS!

Do you have any questions?

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