Technology Implementations for Rural Road Safety Data Collection, Analysis & Visualization

ITA 2022 Annual Meeting

December 2022

Hollyanna Littlebull, Yakama Nation DNR Engineering

Samuel Ricord, University of Washington STAR Lab

Dr. Wei Sun, AIWaysion

Team Members

Yakama Nation DNR Engineering

- HollyAnna Littlebull, Traffic Safety Coordinator
- Dwayne Valentine, Tribal Transportation Program Engineering Lead
- Portia Shields, Data Coordinator

University of Washington STAR Lab

- Dr. Yinhai Wang, Professor
  - Director, Northwestern Tribal Technical Assistance Program (NW TTAP)
  - Director, Pacific Northwest Transportation Consortium (PacTrans)
- Sam Ricord, Research assistant
- Dennis Tsai, Research assistant

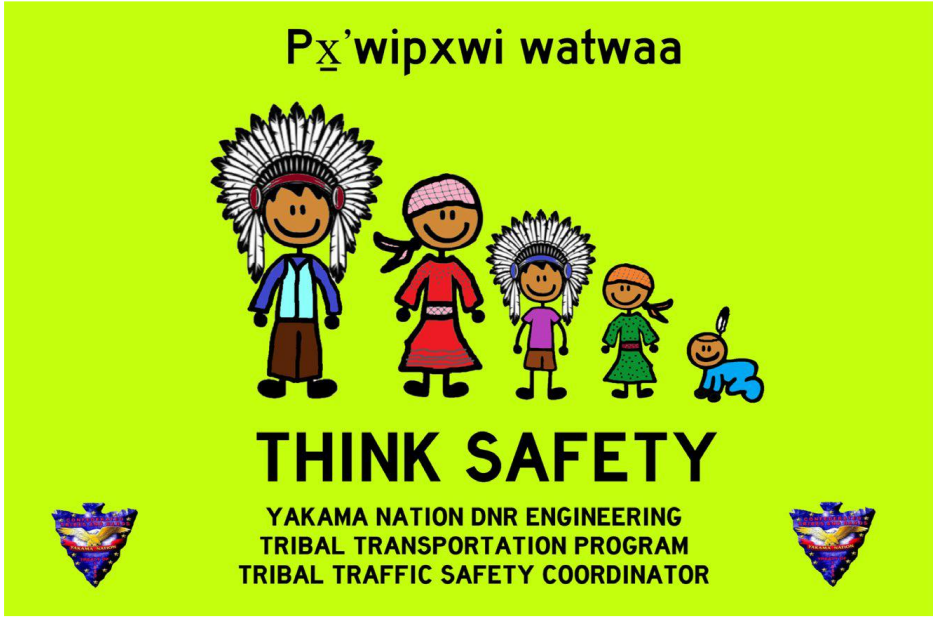
AIWaysion

- Dr. Wei Sun, Chief Executive Officer

Confederated Tribes and Bands of the Yakama Nation

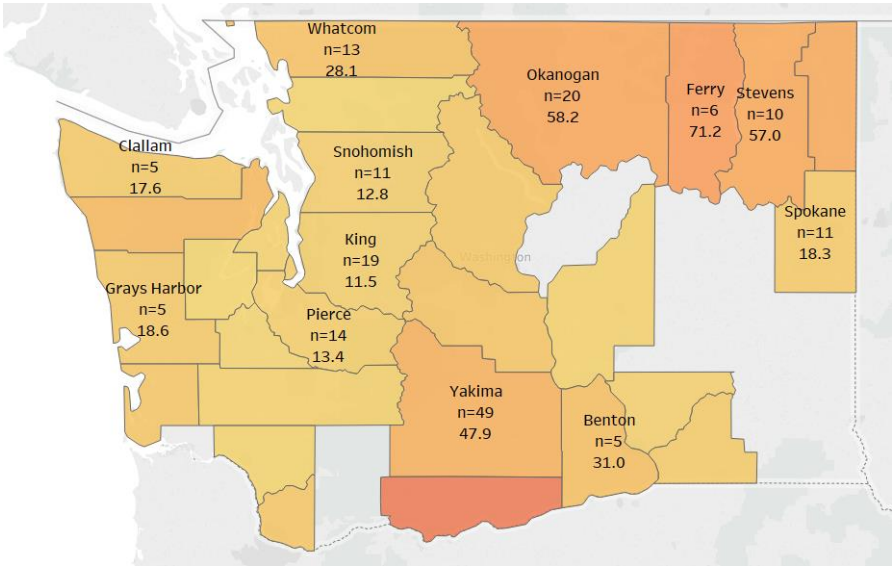
Yakima County

- **Highest number of fatalities** for Native Americans/Alaskan Natives (NA/AN) in vehicle collisions
- **No.1 for NA/AN pedestrian fatalities**



Prevailing Safety Issues of Yakama Nation

Yakima County has one of the highest rates of motor vehicle fatalities for Native American and Alaskan Native Populations in Washington



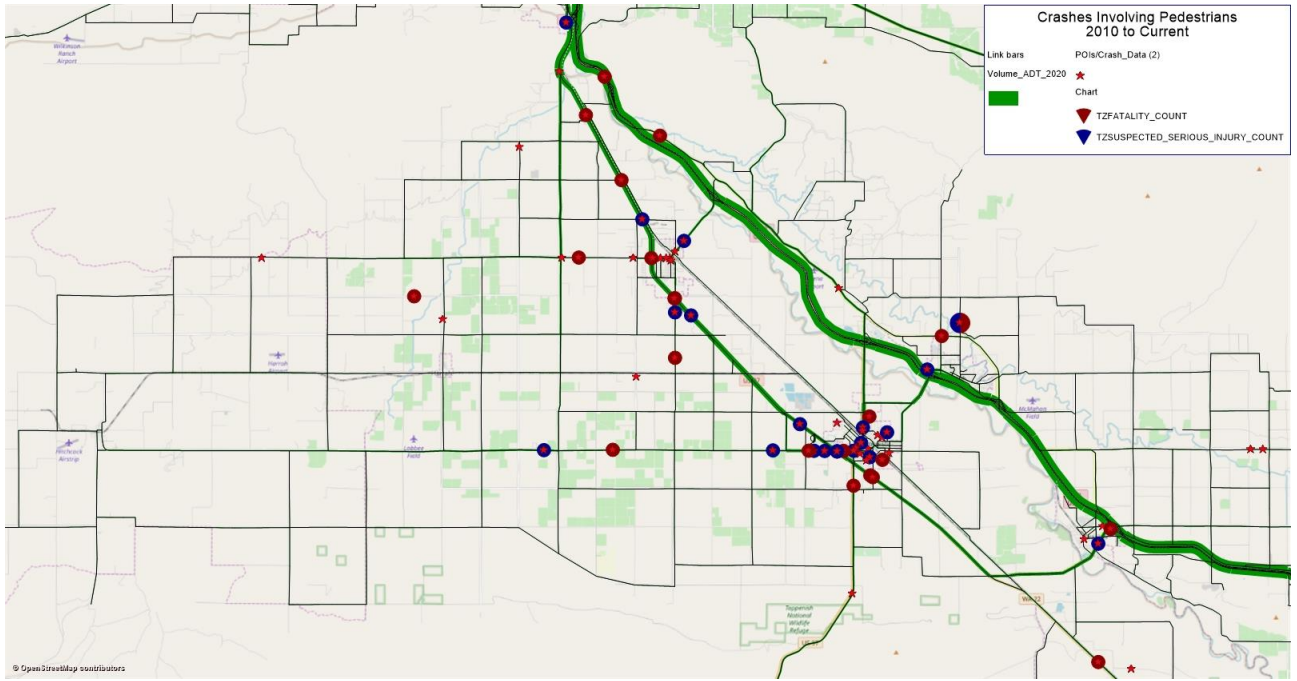
Darker color = higher motor vehicle fatality rates

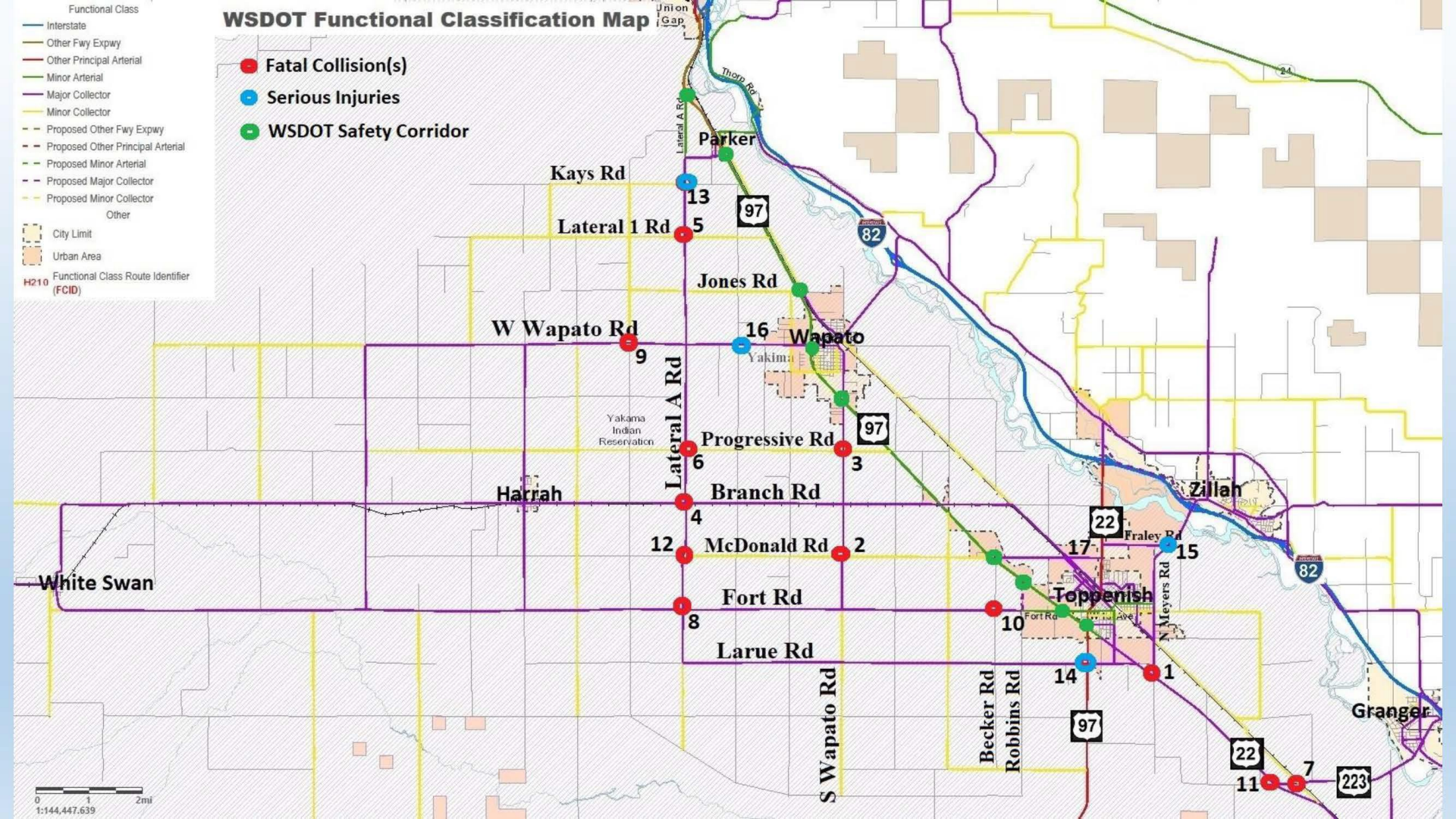
AI/AN Motor Vehicle Fatality Counts and Rates per 100,000 Population by County of Residence, 2011-2016

Source: Washington State death certificates linked to the Northwest Tribal Registry to identify AI/AN race

Prevailing Safety Issues of Yakama Nation

A large portion of these collisions occur on the Yakama Nation reservation and ceded territory




WSDOT Functional Classification Map
Functional Class
Interstate
Other Fwy Expwy
Other Principal Arterial
Minor Arterial
Major Collector
Minor Collector
Proposed Other Fwy Expwy
Proposed Other Principal Arterial
Proposed Minor Arterial
Proposed Major Collector
Proposed Minor Collector
Other
City Limit
Urban Area
H210 Functional Class Route Identifier (FCID)
Fatal Collision(s)
Serious Injuries
WSDOT Safety Corridor
Union Gap
Thorn Rd
Lateral A Rd
Parker
Kays Rd
13
Lateral 1 Rd
5
97
82
Jones Rd
W Wapato Rd
9
16
Wapato
Yakima
Yakama Indian Reservation
Lateral A Rd
Progressive Rd
6
3
Harrah
Branch Rd
4
Zillah
22
Fraley Rd
17
15
12
McDonald Rd
2
White Swan
Fort Rd
8
Toppenish
10
N Meyers Rd
Larue Rd
14
1
S Wapato Rd
Becker Rd
Robbins Rd
Granger
11
7
223
0 1 2mi
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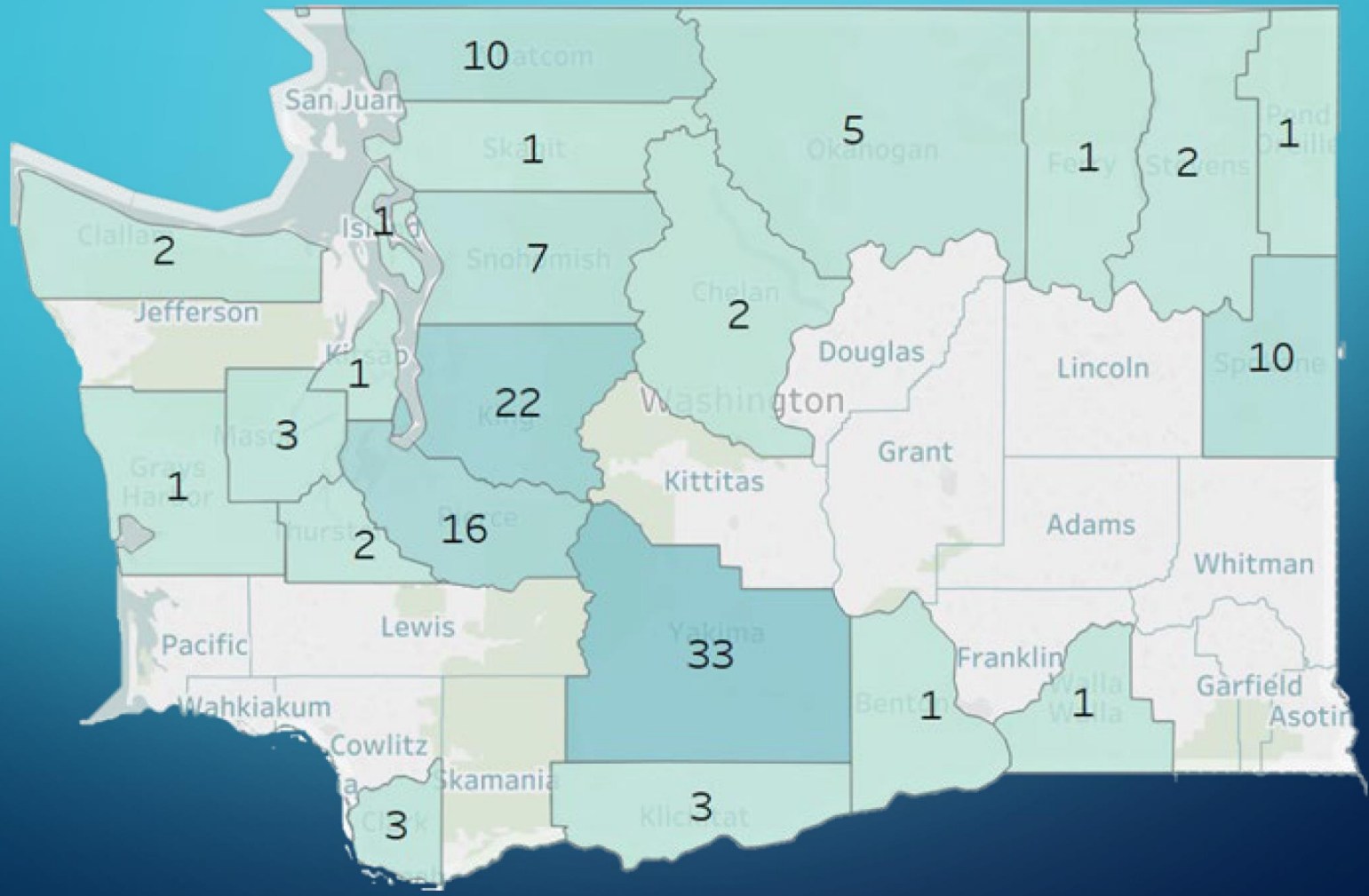

10
San Juan
1
5
1
2
1
1
2
7
Jefferson
2
1
22
2
Douglas
Lincoln
10
3
1
Grant
Kittitas
16
2
Adams
Whitman
Pacific
Lewis
33
Franklin
Garfield
1
1
Wahkiakum
Cowlitz
3
3

Roadway Safety Problems

Roadway geometry

Rural roads with sharp corners, steep grades, and often inadequate shoulders are a major cause of the safety concerns for Yakama Nation.

Adverse weather conditions

Fog, low visibility, snow, ice, and heavy rain, etc.

Human behavior

Many fatalities are exacerbated by human behaviors including speeding, not wearing a seat belt, driving under the influence, and distracted driving.

Comprehensive Roadway Safety Data Visualization and Evaluation Platform - USDOT Safety Data Initiative

Objectives

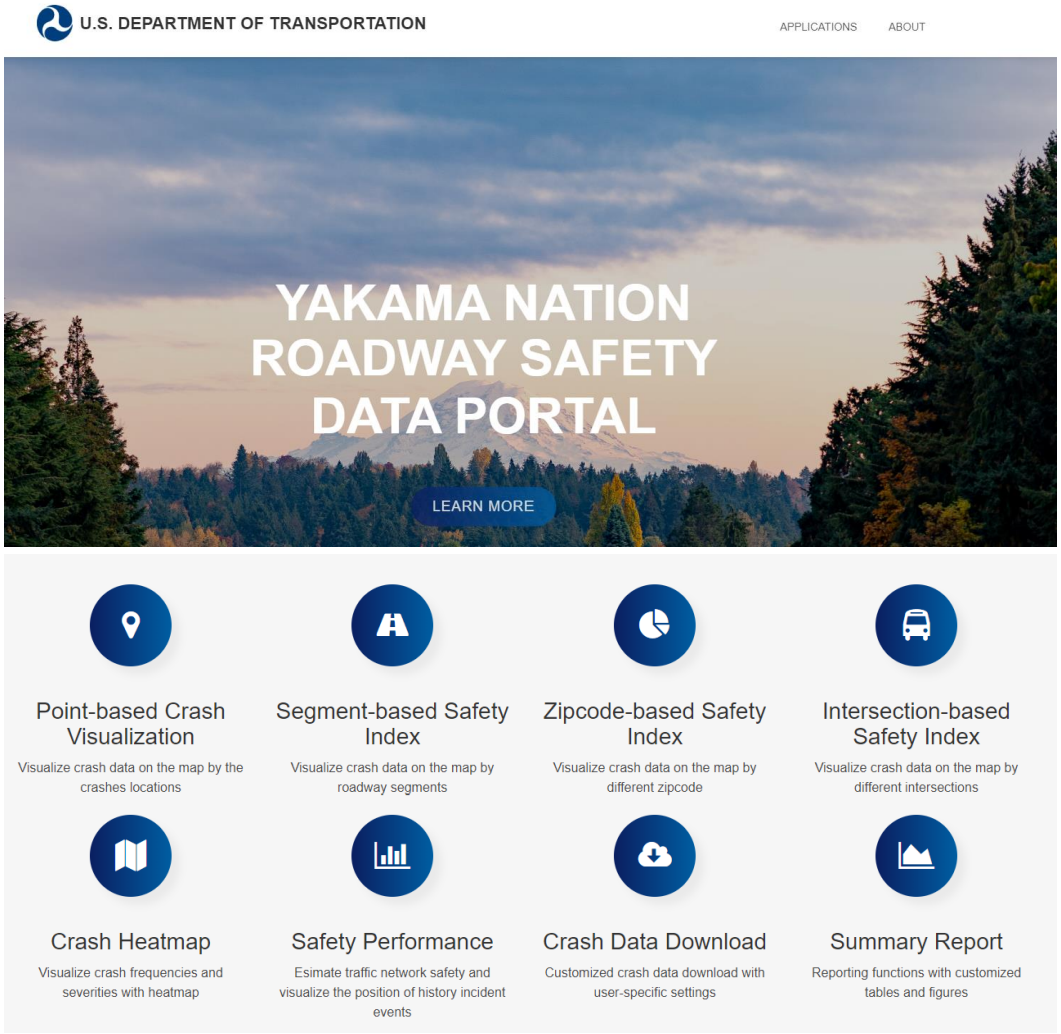
- Address the traffic safety issues through the development of a web-based comprehensive roadway safety tool
- Establish access and better management of multi-source traffic safety related data, both the public available state and county data and local datasets
- Target users: traffic planners and engineers of Yakama Nation DNR Engineering

United State Department of Transportation

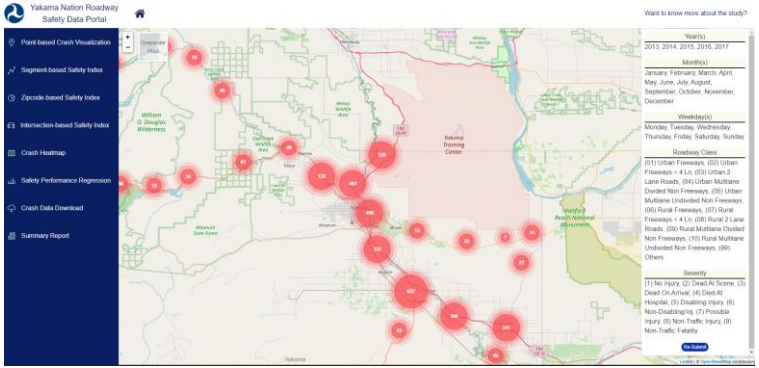
- Paul Teicher, Senior Policy Analyst
- Tom Bragan, Traffic Records Division, NHTSA

Yakama Nation Safety Data Portal

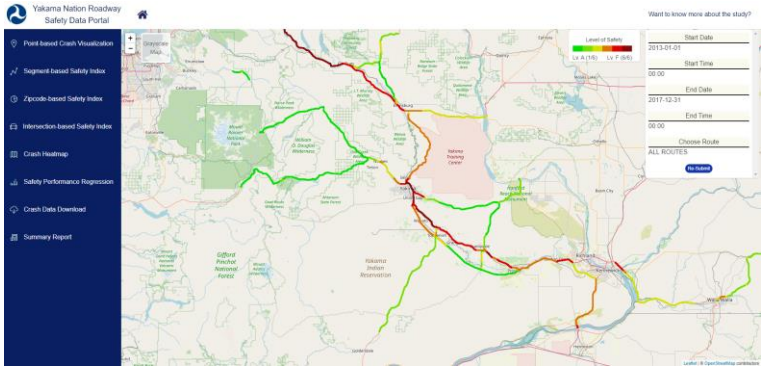
- GitHub repository: (https://github.com/AI-Group-STAR-Lab-UW/yakama-nation-roadway-safety-data-portal)
- Training to Yakama Nation Employees on “Safety Data Collection, Management, and Analytics Technologies”
  - May 19th, 2022 at the UW STAR Lab



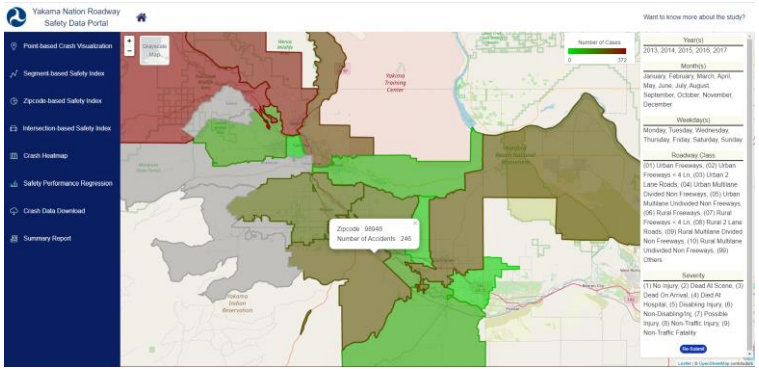
Yakama Nation Safety Data Portal



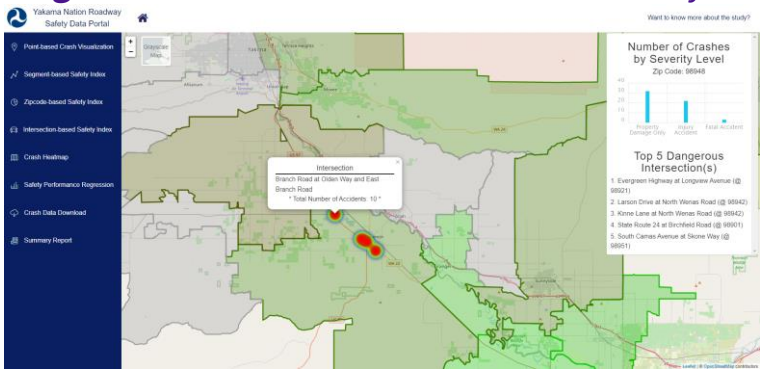
Point-Based Crash Visualization



Segment-Based Crash Visualization & Safety Performance



Area-Based Crash Visualization



Intersection-Based Crash Visualization

Roadway Safety Data

- **Collision data from various agencies/online resources**
  (Source: HSIS, Washington State Crash Data Portal, Yakama Nation DNR Engineering)
  - Collision Subfile – contains general collision data.
  - Vehicle Subfile – contains general data on individual vehicles in collisions.
  - Occupant Subfile – contains information on each occupant of vehicles.
  - Pedestrian Subfile – contains information on each pedestrian involved in a collision.

HSIS
HIGHWAY SAFETY INFORMATION SYSTEM

WSDOT

Roadway Safety Data

- **Map and Roadway Geometry data**

  (Source: HSIS, Washington State Department of Transportation Geospatial Open Data Portal, OpenStreetMap)

  - Roadlog file contains information on the general characteristics of the roadways.
  - Curve and Grade Files provide curve and grade information.
  - Ramp File indicates info on any ramps that are used on the roadway.
  - Special-Use Lane File which defines lanes with special uses.
  - Features File contains info on miscellaneous roadway features.
  - Left/Right File contains information on the terrain flanking roadways.
  - Railroad Grade Crossing Index contains information where railroads cross the state highways.
  - Traffic Information Index provides various traffic metrics for each road segment.

Traffic Safety Analysis

- Dependent variable is crash injury severity level
  - fatal, injury (non-fatal), and property damage only (PDO)
- 21 explanatory variables
  - roadway geometrics
  - vehicle information
  - traffic characteristics
  - driver characteristics
  - temporal features
  - crash information
  - environmental conditions

Variable		Definition	Range/Categories
Crash Injury Severity		Crash injury severities	Fatal, Injury, PDO
Roadway Geometrics	Road Surface Material	Surface material type	Asphalt, Bituminous, Gravel, Portland Concrete Cem, Soil, Other
	Lane Width	Calculate lane width: calculated by dividing the total roadway width by the total number of lanes	Continuous, in ft
	Roadway Width	Total roadway width for the roadway segment	Continuous, in ft
	Degree of Curvature	Degree of curvature for the curve: calculated from curve radius	Continuous, in ft
	Left Shoulder Width	The width of the inside (left) shoulder of road in feet in the increasing direction of the roadway.	Continuous, in ft
	Right Shoulder Width	The width of the outside (right) shoulder road in feet in the increasing direction of the roadway.	Continuous, in ft
	Grade Percentage	Percent grade for this roadway segment	Continuous, in %
Vehicle Information	Truck	If the involved vehicle is truck	Yes, No
	Old Car	If the involved vehicle was more than 15 years old at the time of crash	Yes, No
Traffic Characteristics	AADT	Calculated Annual average daily traffic (AADT)	Integer
	Truck percentage	Truck percentage for the roadway segment	Continuous, in %
	MVMT	Million vehicle miles traveled on road segment	Continuous, in veh-mile

Traffic Safety Analysis

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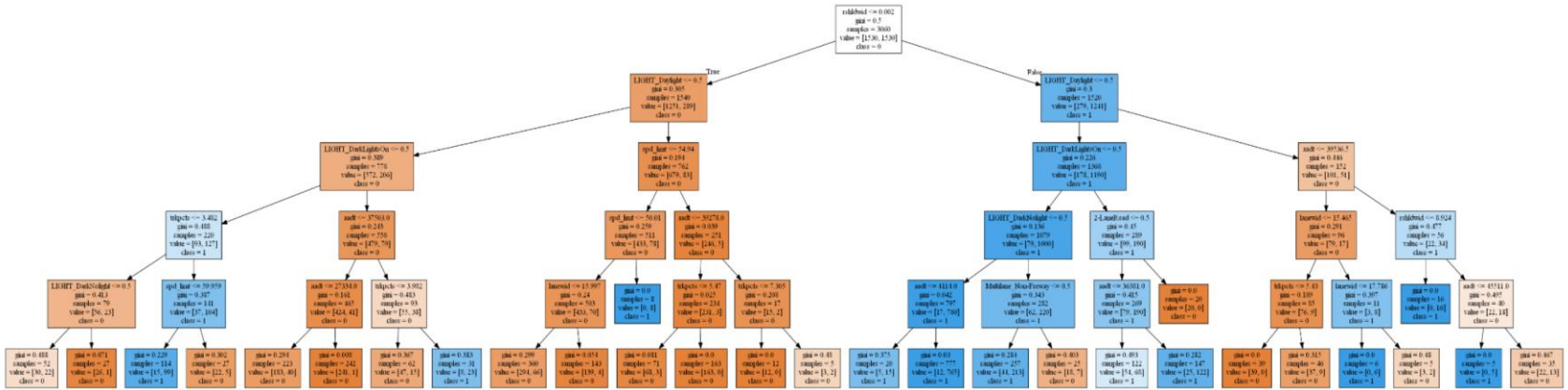
  - driver characteristics
  - temporal features
  - crash information
  - environmental conditions

Variable		Definition	Range/Categories
Crash Injury Severity		Crash injury severities	Fatal, Injury, PDO
Driver Characteristics	Driver's Gender	Driver's gender	Male, Female
	Young Driver	If driver is younger than 25 years old	Yes, No
	Old Driver	If driver is older than 65 years old	Yes, No
	Drunk Driver	If driver had been drinking and ability had been impaired	Yes, No
Temporal Features	Day	Day of week when the crash occurred	Weekday, Weekend
	Hour of Day	Hour of day when the crash occurred	0-23
	Peak-hour	If accident took place in peak hours, i.e. 7-10am, 5-8pm	Yes, No
Crash Information	Type	Type of crash that occurred: developed by WA DOT staff using vehicle maneuvers	Head On, Rear End, Road Departure, Strikes at Angle, Sideswipes, Vehicle Rollover, Strikes Animal, Strikes Appurtenance, Strikes Other Objects, Pedestrian/Bicycle Involved, Non-Collision Fire, Other
	Location	Location where the crash occurred	Rural-Minor-Arterial, Rural Minor Collector, Rural Local Roads, Other
Environmental Conditions	Light	The type/level of light that existed at the time of the crash	Daylight, Dawn, Dusk, Dark
	Weather	Weather conditions when the crash occurred	Clear, Overcast, Raining, Snowing, Fog, Severe Crosswind, Other
	Roadway Surface Conditions	The condition of the road surface where the crash occurred	Dry, Wet, Snow/Slush, Ice, Other

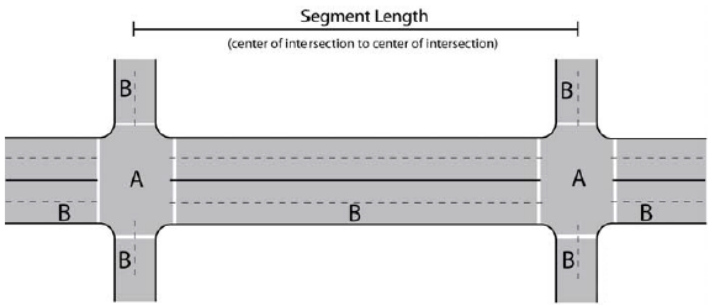
Machine Learning Approaches for Traffic Safety Analysis

- **Several ML methods used to understand and predict pedestrian fatalities in rural areas of Washington State**
  - Decision Tree and Random Forest had best performance
  - TRB 2022 Annual Conference presentation



Segment-based Safety Index

- **Road segment performance regression**
  - Segment-based regression model for crash prediction considering significant factors such as lane width, shoulder width, median width, number of lanes, etc.



$$N_i = \beta_o L_i (AADT_i)^{\beta_1} e^{\beta_2 W_L + \beta_3 W_S + \beta_4 W_M + \beta_5 N_L} \quad (4)$$

Table 1. Variables of Prediction Model in Equation (4)

Variables	Descriptions
$AADT$	Two-way average traffic volume
Segment Length L	Length of homogenous segments
Lane Width W_L	Average width of all lanes
Shoulder Width W_S	Average width of the shoulder center in the two opposite directions
Median Width W_M	Average median width along segments
Number of Lanes N_L	Number of total lanes within the segment

Results Sharing & Peer Exchange

- ❑ Presentations at the Yakama Nation Traffic Safety Committee Meetings
- ❑ Invited talk at 2021 National Transportation in Indian Country Conference (NTICC)
- ❑ Invited talk at 2021 Highway Safety Information System (HSIS) Annual Liaison Meeting
- ❑ Presentation at 2022 TRB Annual Meeting

TRB
TRANSPORTATION RESEARCH BOARD

HSIS
HIGHWAY SAFETY INFORMATION SYSTEM

Continued Efforts

- Safety data portal for multi-source data management
  - Yakama Nation DNR Engineering team to include and management more datasets
    - Pedestrian safety data
    - Local Roadway Geometry Data
    - Tribal Police Department data
  - UW STAR Lab will provide technical assistance to the traffic engineers and planners of Yakama Nation DNR
    - Data management
    - Maintenance
    - Visualization & analytical functions

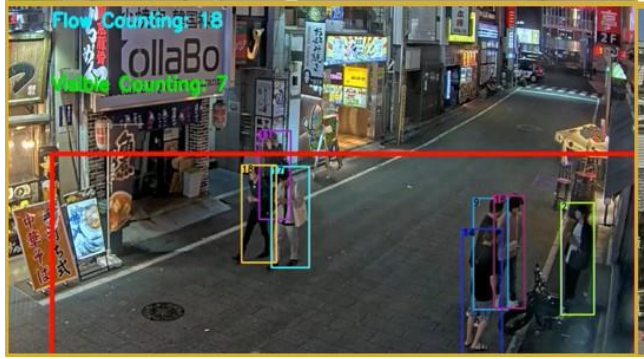
Safety Data Collection Pilot Project in Yakama Nation

- Address the **lack of data** challenge in rural roads
  - lack of funding and infrastructure support for deploying data collection equipment in low-volume rural roads
  - lack the personnel and technologies
  - specific data collection needs: agricultural vehicles, roadway and environmental conditions (snow/ice on the roadway, heavy fog, smoke/fire, etc.)

MUST Device (Plug and play, easy to install)

Vehicle detection, tracking, counting

Road surface conditions (normal, dry, snow, icy)



Pedestrian detection and counting

Multi-modal detection (car, truck, bus, pedestrian, cyclist, scooter, etc.)

Cost-Effective System for Rural Roadway Traffic, Surface Conditions and Weather Conditions Monitoring

- Cost-effective roadside device
  - **Traffic**, **roadway**, and **environmental** conditions detection, and **dangerous events** detection and warning
  - **In-device analysis** (Edge Computing)
    - Does not require high bandwidth internet
    - Protects the privacy of the community
  - **Plug-and-play** solution, and does not require tech-personnel to maintain the system

Mobile Unit for Sensing Traffic (MUST)

STARLab 11111010011

CSET rural · isolated · tribal · indigenous

AIWaysion

Location: Larue Rd and Highway 97, Toppenish, WA

The danger zone

Green energ
Yakamas
request mo
consultatio
on projects

Yakama Power lineterman Garrett Ambrose discusses the installation of the Mobile Unit for Sensing Traffic on a power pole with Wei Sun, CEO of AIWaysion, at the intersection of Larue Road and U.S. Highway 97.

Photos by Jasper Sundeen, Yakima Herald-Republic

Yakama Nation seeking safer roads, better data with sensor outside Toppenish

JASPER KENZO SUNDEEN
YAKIMA HERALD-REPUBLIC

A new sensor at the intersection of Larue Road and U.S. Highway 97 will provide more information to improve traffic safety in what can be a dangerous part of the Yakima Valley.

Yakama Nation's Department of Natural Resources collaborated with the University of Washington's Smart Transportation Applications and Research Lab and AIWaysion to install the sensor, called a Mobile Unit for Sensing Traffic, this week.

"This is the deadliest intersection on the reservation," explained HollyAnna Littlebull, traffic safety coordinator at the Yakama Nation.

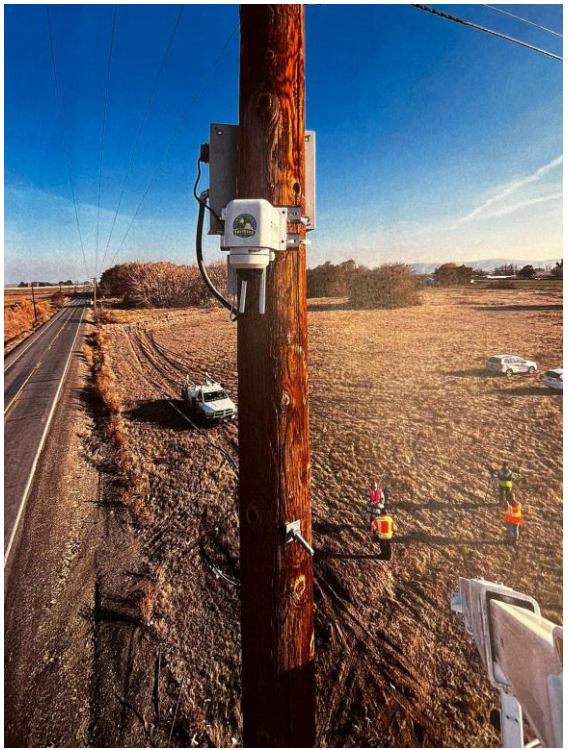
Seven fatalities and more than 30 collisions have occurred at the intersection of Larue Road and Highway 97. The sensor could inform drivers of road conditions and give planners more data moving forward.

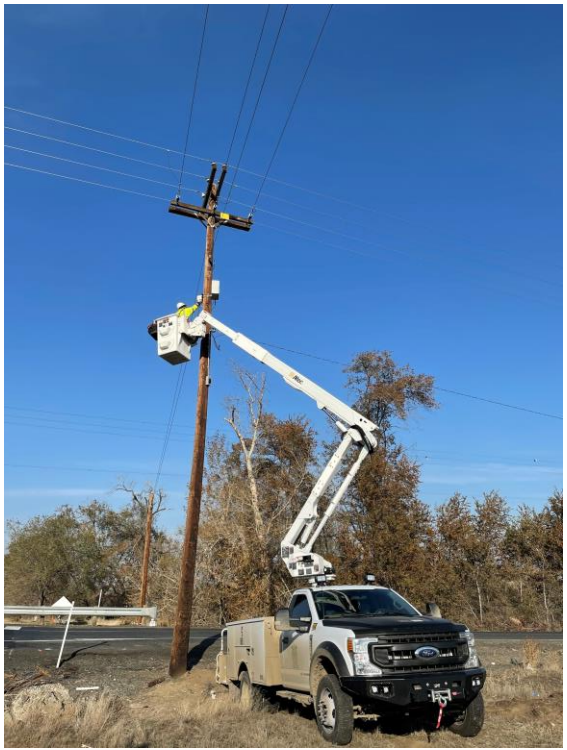
"We want to see what kind of users are using this intersection ... We need to know the volume, the types of vehicles," Littlebull said. "We're trying to make data-informed decisions."

It's a pilot project, said Littlebull, and was funded by a grant from the University of Washington. Littlebull said that once the device was properly tested, it would produce data for real-time road conditions. That could be helpful when visibility is low, during foggy or smoky days.

SEE SAFETY PAGE 2A

AIWaysion project manager Luyang Gong, left, and HollyAnna Littlebull, traffic safety coordinator at the Yakama Nation Department of Natural Resources, look at the first results from the Mobile Unit for Sensing Traffic.

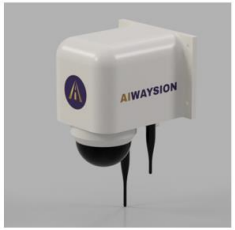




https://www.yaktrinews.com/yakama-nation-installs-traffic-data-sensor-at-deadly-intersection-on-us-97/
https://kimatv.com/news/local/traffic-sensor-along-us-97-to-provide-more-insight-for-improvements-along-corridor

Location: Larue Rd and Highway 97, Toppenish, WA

Dashboard: device management, real-time data collection, event detection & warning



Toppenish1 Online

Location: US-97 & Larue Rd, Toppenish, WA 98948

Installed at: 2022-11-15 15:26:30

Last updated at: 2022-12-04 20:30:00

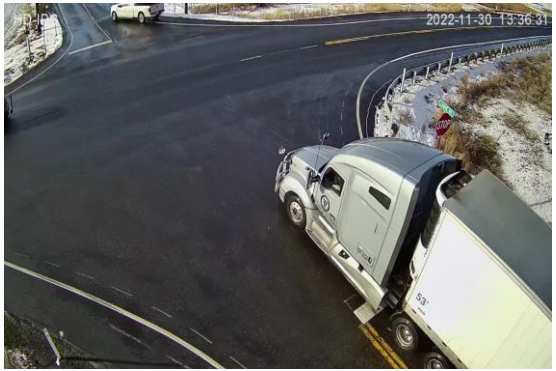
Overview

-3 °C
Temperature

66.4 %
Humidity

Snow
Road Condition

35.0 mph
Traffic Speed

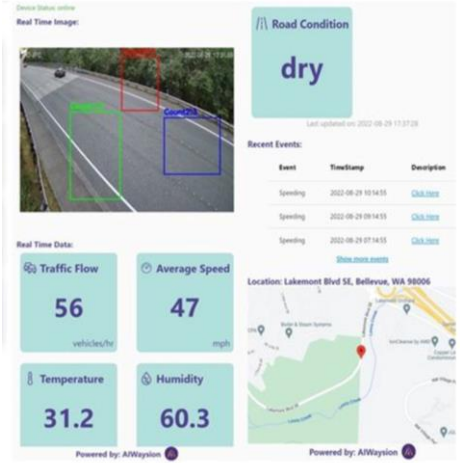


Next Steps

- Data collection to support countermeasures implementation/grants application for funding
  - Semi-trucks, Agricultural vehicles
  - Pedestrian safety
  - Heavy fog/low visibility
  - Human behavior: speeding, fail to stop at stop sign
- More devices installation
  - Fort Rd & Lateral A
  - US 97 & S Wapato
  - US 97 & McKinley
  - Fort Rd & Elmwood

Next Steps

- Traveler information & warning system
  - Dashboard and mobile app to communicate with Yakama Nation DNR Engineering
  - Variable message signs to alert travelers
  - Pedestrian safety APP



Thanks!
Questions?

Feel free to reach out with any other questions you may have!

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