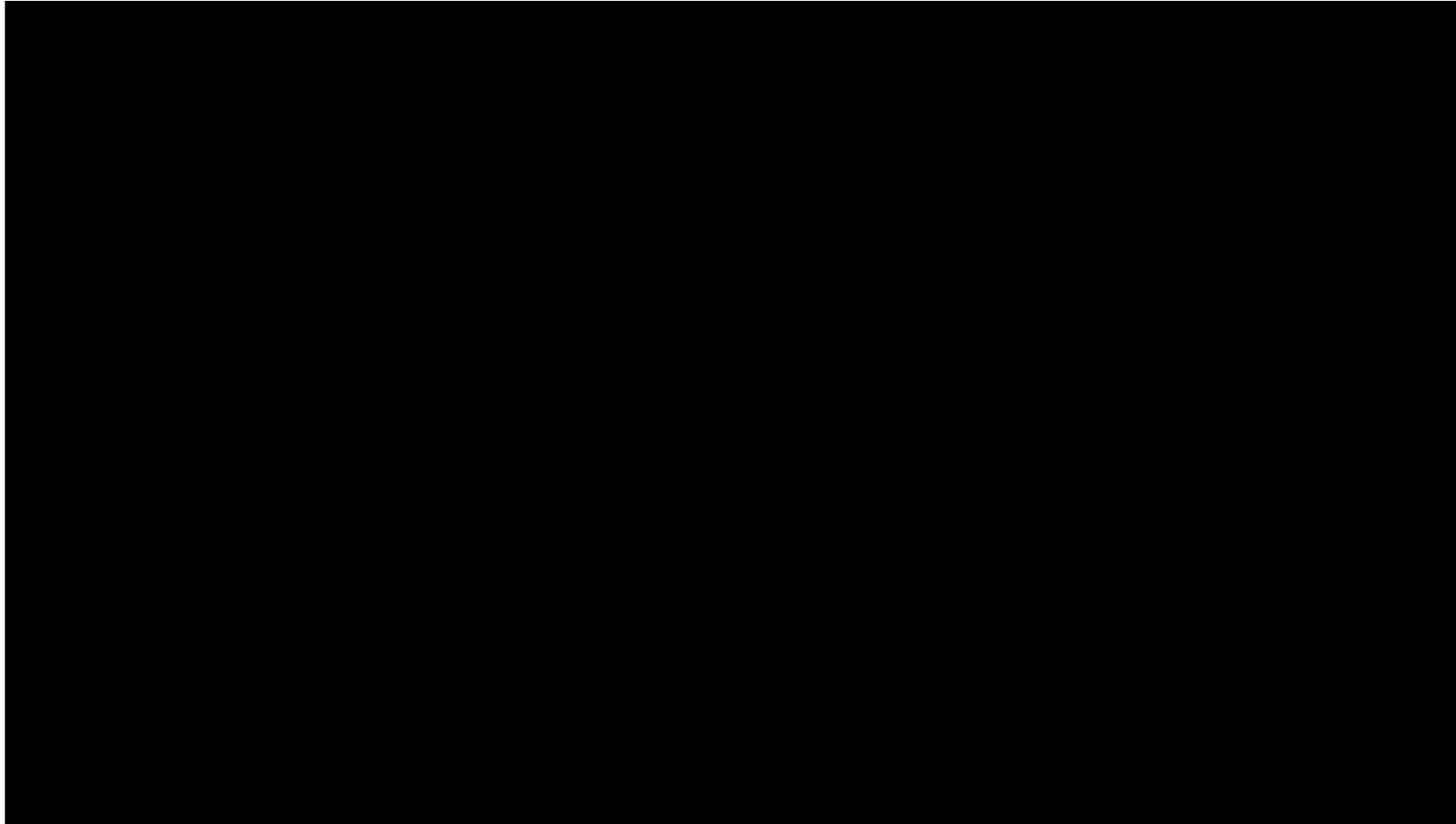


Development of Safety Testing for Automated Driving Systems (ADS) Equipped Vehicles

Michelle Chaka, Interim Director
Center for Public Policy, Partnerships, and Outreach
Virginia Tech Transportation Institute

SIP-agus Workshop 2019
Safety Assurance



Autonomy: *a cinematic exploration of the history and state of automated driving technology*
Documentary Release November 15, 2019

Dr. Sadayuki Tsugawa



In 1977, under Japan’s Ministry of International Trade and Industry (MITI), Tsugawa-san and his team of researchers turned a black Toyota sedan into what is now credited as the “world’s first autonomous car.”

ADS Technology “Deployments”

Technically, most companies/organizations are just testing, but this testing involves more than engineers monitoring ADS performance and tracking disengagements:

Examples of on-road automated Testing Locations:

- Canada
- United States
- United Kingdom
- Netherlands
- France
- Finland
- Switzerland
- Germany
- Israel
- Russia
- China
- Japan
- Singapore
- Australia
- New Zealand

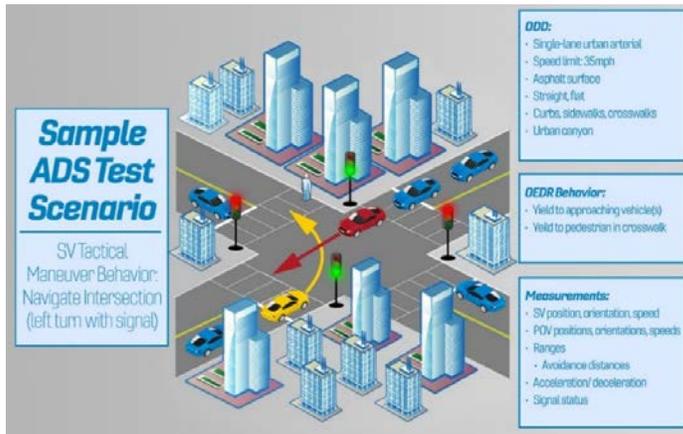


Development of Safety Testing for ADSs

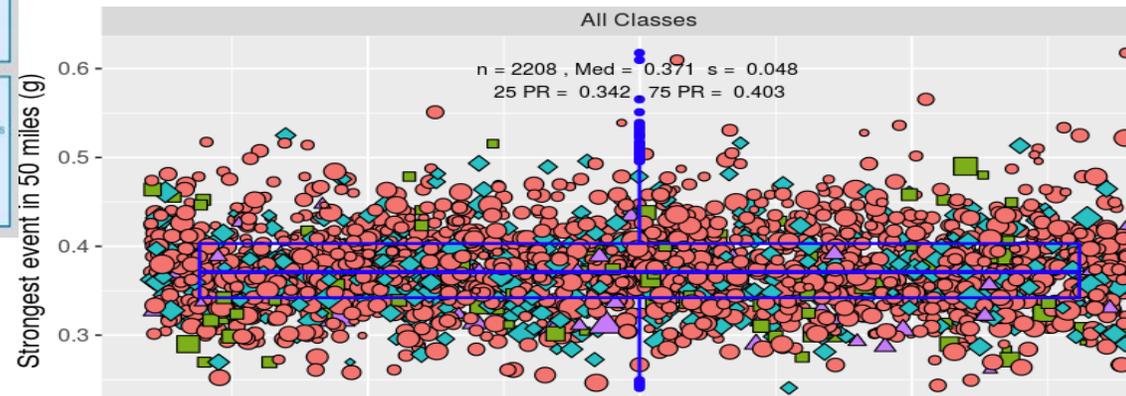
The development of safety testing for ADSs is needed and will not happen overnight

...establishing a thoughtful methodology that allows testing to evolve with the technology will be critical to addressing the complexity of ADSs safety testing.

Testing Framework



Data and Analysis for Framework Implementation

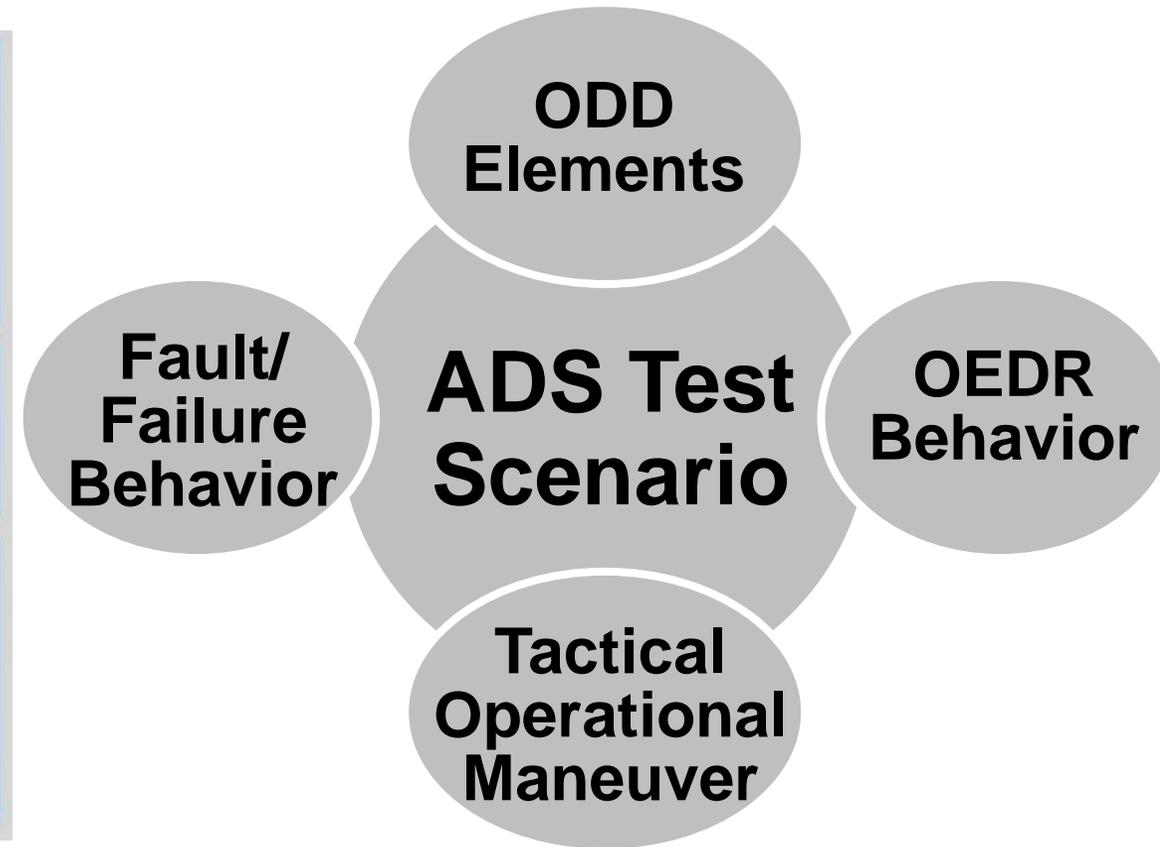
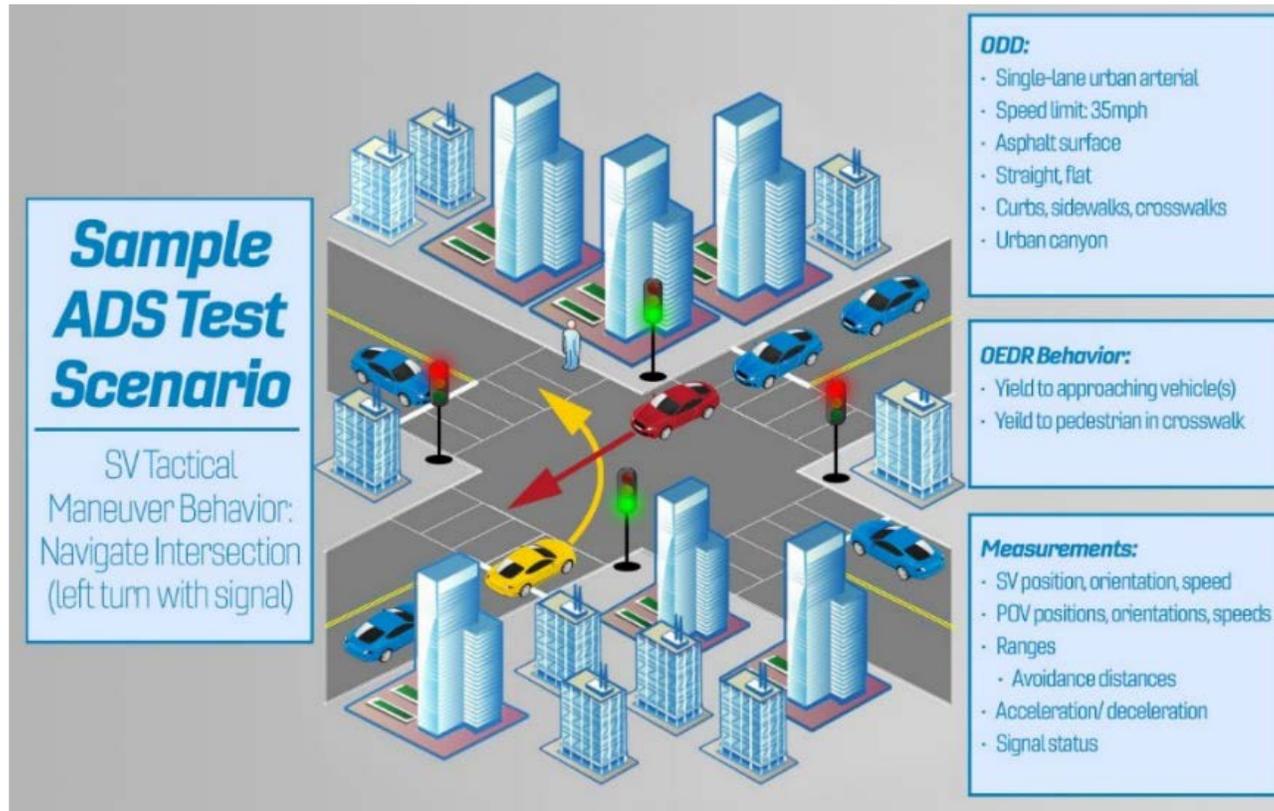


Real-world Deployment Considerations



Development of Safety Testing for ADSs: Testing Framework

NHTSA's Testable Cases and Scenarios for Automated Driving Systems created a framework for describing an ADS test scenario; however, more research is needed to identify testable cases and associated test architecture.

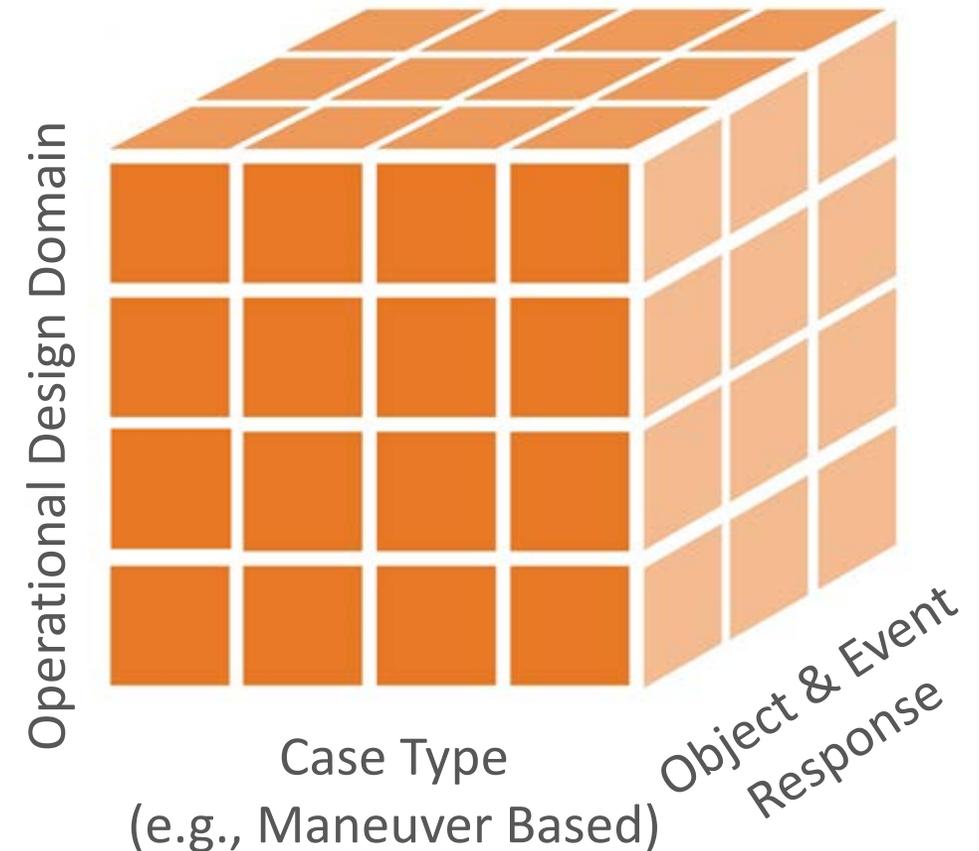


Reference:

Thorn, E., Kimmel, S., and Chaka, M. (2018, September). A framework for automated driving system testable cases and scenarios (Report No. DOT HS 812 623). Washington, DC: National Highway Traffic Safety Administration. URL: https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13882-automateddrivingsystems_092618_v1a_tag.pdf

Development of Safety Testing for ADSs: Data and Analysis for Framework Implementation

Safety testing (specifically identifying test cases) starts with the data and knowledge we have today.



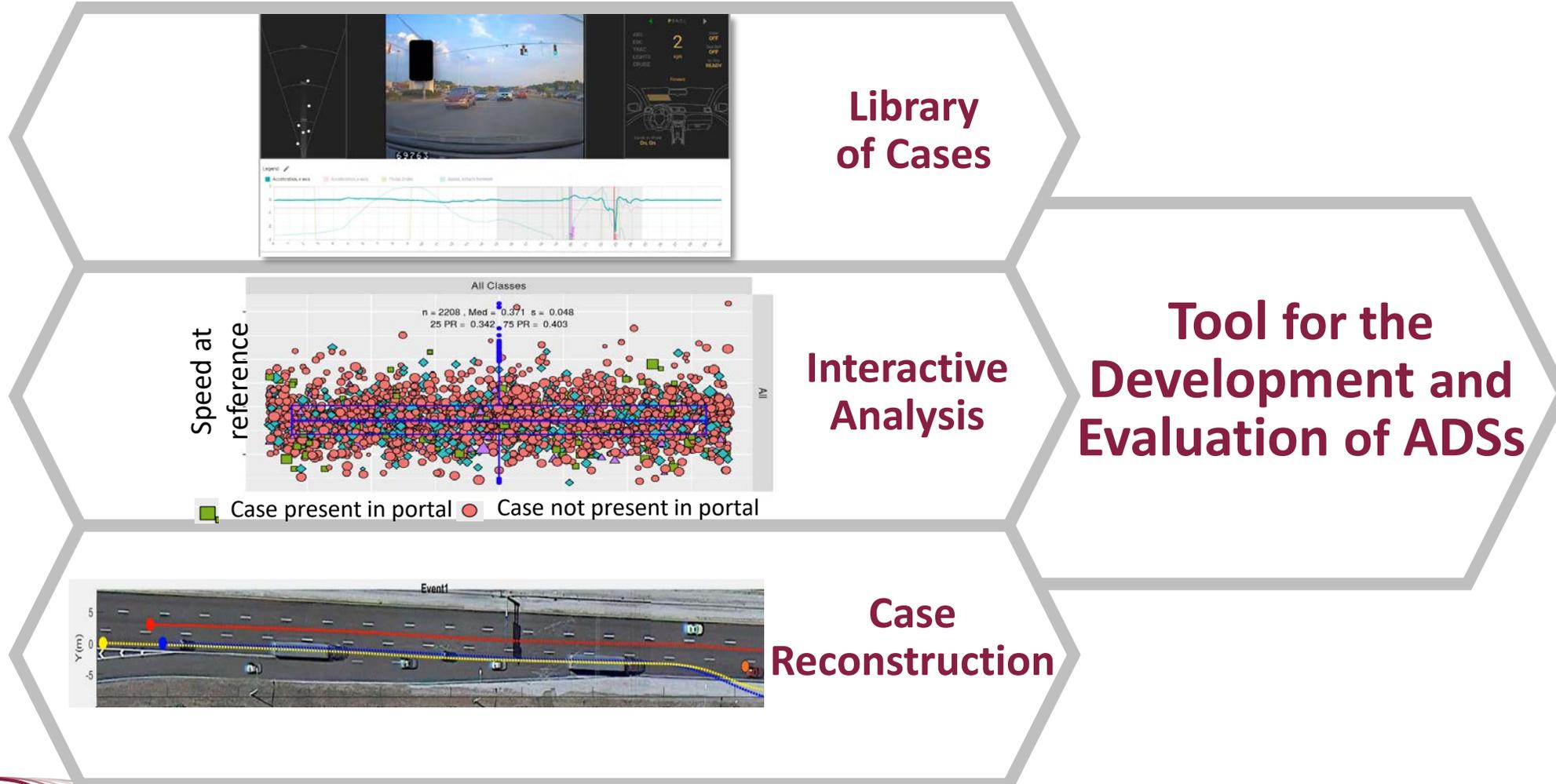
AMP

Automated Mobility Partnership

An industry partnership promoting the development of tools, techniques, and data resources to support the rapid advancement of automated-vehicle deployment for its members.

Development of Safety Testing for ADSs: Real-world Cases, Analytics and Tools

VTTI's AMP Program is working to support the rapid advancement of ADS deployment.



AMP Library: Case Browser

Near-crashes, Night, Crosswalk

AMP SCENARIOS MEMBERS SUPPORT Michelle Chalka

AMP Scenarios

Case ID or Text Search

Quick Filters: Near-crash, Crosswalk (with or without pedestrian(s)), Night

My Tags: Animal (3), Construction Merge (2), Deer (2)

Case Type: Crash (2), Near-crash (129), Seaside (2), Speed (2)

AMP Layer: Algorithm (121), Augmented (52), Visualization (4)

Initial Manuever: Going straight (35), Curve (5), Right turn (3), Left turn (14), Uturn (0), Lane change (2), Merge (2), Avoidance (0), Steering (4), Stopped (2)

Interactions: With a lead (20), With oncoming (1), Uturn (22), Short following (1), With following vehicle (4), With adjacent vehicle (2), Across path, same direction (2), Across path, opp direction (17), Into path, same direction (7), Into path, opp direction (5)

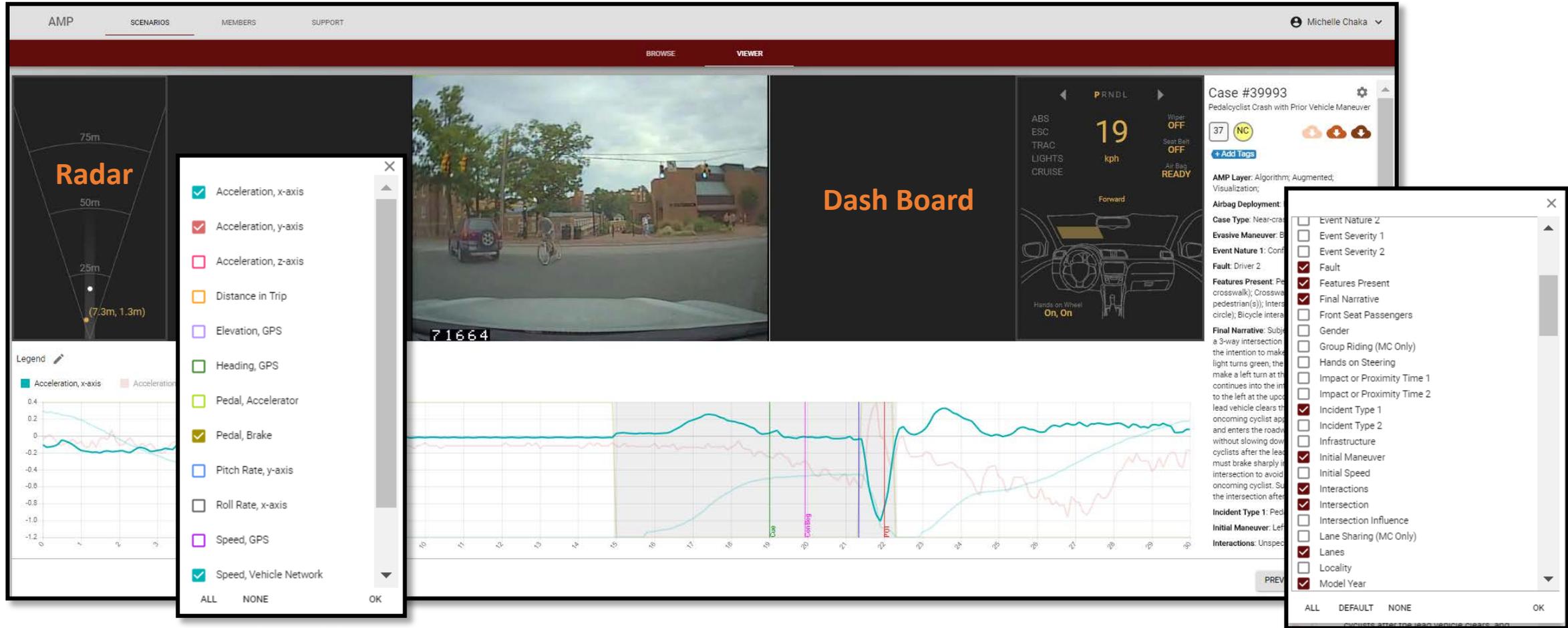
Roadway Geometry: Curved (14), Straight (124), Grade (22)

Sort By: Case ID

196	37556	37612	37622	37722	37762	37790	37861	37864	37984
14 NC	59 NC	0 NC	61 NC	55 NC	50 NC	55 NC	48 NC	51 NC	0 NC
Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Curve, Weather, Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Traffic calming device, Construction Zone, Crosswalk (with or without pedestrian(s))	Crosswalk (with or without pedestrian(s))	Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Pedestrian (other than at crosswalk), Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle), Animal, Intersection	Weather, Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Weather, Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)
37992	38005	38033	38045	38099	38156	38191	38241	38287	38406
42 NC	22 NC	16 NC	0 NC	0 NC	58 NC	34 NC	40 NC	22 NC	1 NC
Curve, Weather, Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Weather, Pedestrian (other than at crosswalk), Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Curve, Pedestrian (other than at crosswalk), Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Curve, Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Curve, Weather, Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Weather, Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle), Urban grid	Traffic cone, Weather, Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)
38418	38426	38508	38516	38544	38570	38618	38710	38730	38784
45 NC	0 NC	31 NC	60 NC	41 NC	0 NC	0 NC	0 NC	52 NC	32 NC
Pothole, Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle), Challenging road edge	Pedestrian (other than at crosswalk), Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Pedestrian (other than at crosswalk), Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Curve, Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle), Challenging road edge	Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle), Urban grid	Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Construction Zone, Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle), Urban grid	Curve, Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)	Weather, Pedestrian (other than at crosswalk), Crosswalk (with or without pedestrian(s)), Intersection (other than traffic circle)
38814	38874	38876	38904	38910	39002	39076	39194	39227	39279
47 NC	47 NC	56 NC	54 NC	0 NC	44 NC	54 NC	30 NC	30 NC	40 NC
Weather, Crosswalk (with or without pedestrian(s))	Construction Zone, Crosswalk (with or without pedestrian(s))	Short following/plansign, Weather, Crosswalk (with or without pedestrian(s))	Short following/plansign, Weather, Crosswalk (with or without pedestrian(s))	Crosswalk (with or without pedestrian(s)), Intersection	Crosswalk (with or without pedestrian(s)), Intersection	Curve, Weather, Crosswalk (with or without pedestrian(s))	Weather, Crosswalk (with or without pedestrian(s))	Police/Traffic, Weather, Traffic calming device, Pedestrian	Weather, Crosswalk (with or without pedestrian(s))

<https://vti-amp.org/scenarios/viewer>

AMP Library: Case Viewer



The screenshot displays the AMP Case Viewer interface for Case #39993, titled "Pedal cyclist Crash with Prior Vehicle Maneuver". The interface includes a top navigation bar with "AMP", "SCENARIOS", "MEMBERS", and "SUPPORT". The main content area is divided into several panels:

- Radar:** A radar view showing a 75m range with a 50m and 25m inner range. A target is identified at (7.3m, 1.3m).
- Dashboard:** A digital instrument cluster showing "19 kph", "Wiper OFF", "Seat Belt OFF", and "Air Bag READY". It also displays "ABS", "ESC", "TRAC", "LIGHTS", and "CRUISE" status.
- Video Feed:** A live video feed of a street scene with a car and a cyclist. The license plate "71664" is visible.
- Data Graph:** A line graph showing various variables over time, with vertical lines indicating "Bus", "Coming", and "POT" events.
- Case Details:** A panel on the right containing case information, "AMP Layer" details, "Airbag Deployment" status, "Case Type", "Evasive Maneuver", "Event Nature", "Fault", "Features Present", "Final Narrative", "Incident Type", "Initial Maneuver", and "Interactions".

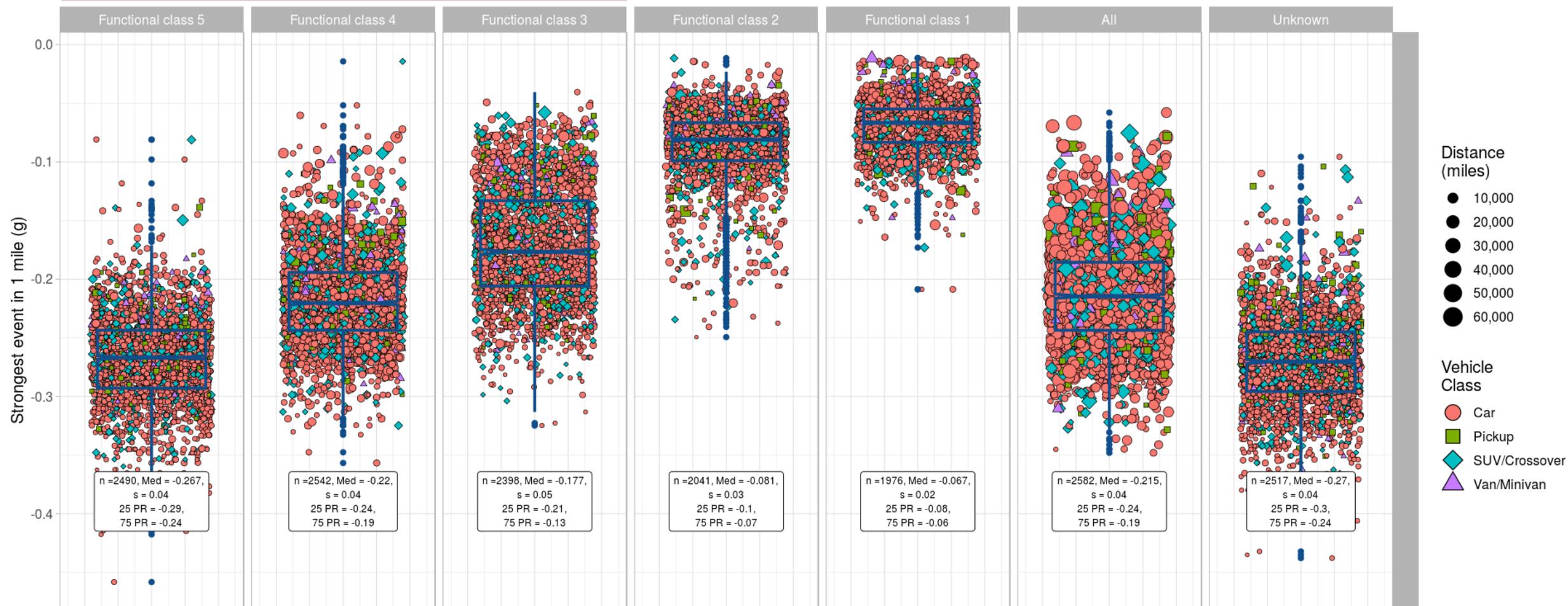
Two pop-up windows are overlaid on the interface:

- Selectable Variables:** A window with a list of variables and checkboxes. The "ALL" button is selected.
- Selectable Annotation Elements:** A window with a list of annotation elements and checkboxes. The "ALL" button is selected.

Selectable Variables

Selectable Annotation Elements

Strongest Event in 1 Mile (g)



AMP Near Crash Left Turn Across Path From Opposite Directions Example Case



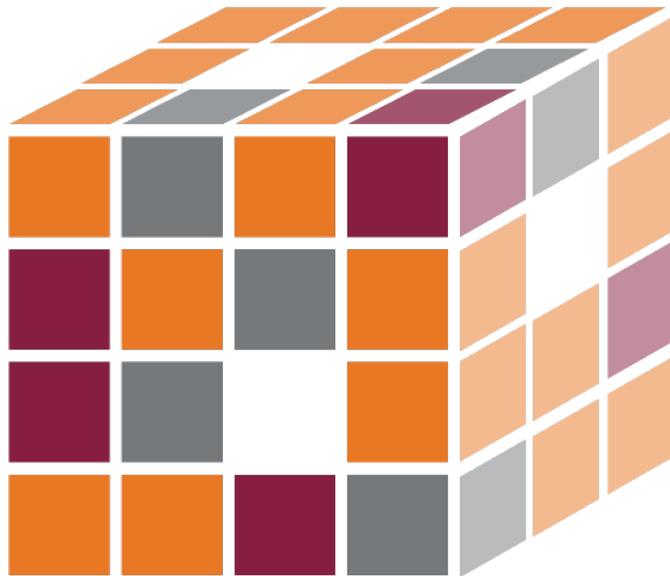
AMP Near Crash Left Turn Across Path From Opposite Directions Example Case





Development of Safety Testing for ADSs: Data and Analysis for Framework Implementation

The complexity of the ADS and potential test cases may require a multifaceted testing architecture.



Coping with Variability and Uncertainty

Operational design domains can be limited, but most ADSs will still need to operate in highly dynamic domains (e.g., environmental, situational).



No two work zones are the same.



Vulnerable road user interactions add to unpredictability and error severity.

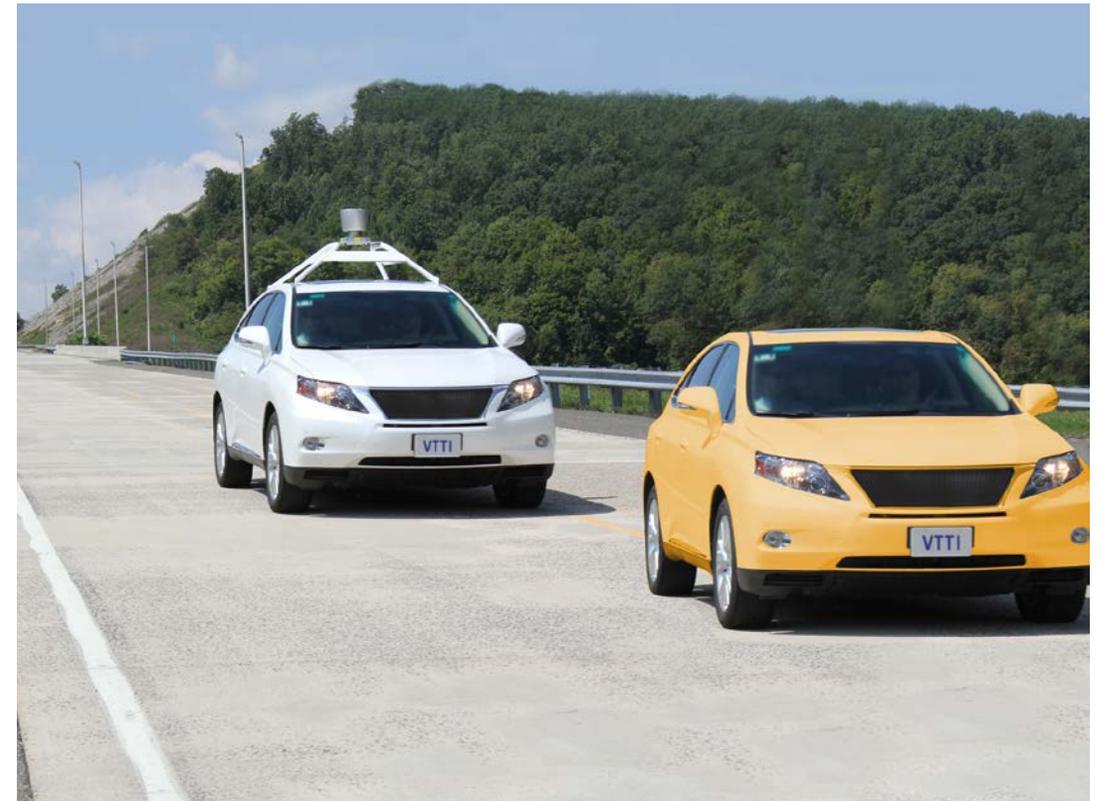


Human drivers, even safe ones, are highly variable.

VTTI Awarded US DOT Grants for Automated Vehicle Research

Two grants totaling \$15 million were awarded to VTTI for advance research on the safe integration of automation into U.S. roadways:

- Safely Operating ADS in Challenging Dynamic Scenarios, An Optimized Automated Driving Corridor Demonstration
- Automated Trucks and Mixed Fleets



Safely Operating ADS in Challenging Dynamic Scenarios An Optimized Automated Driving Corridor Demonstration



Demonstrate
how highly automated vehicles
safely interact in dynamic
scenarios including interaction
with public safety and
cooperative freeway
operations

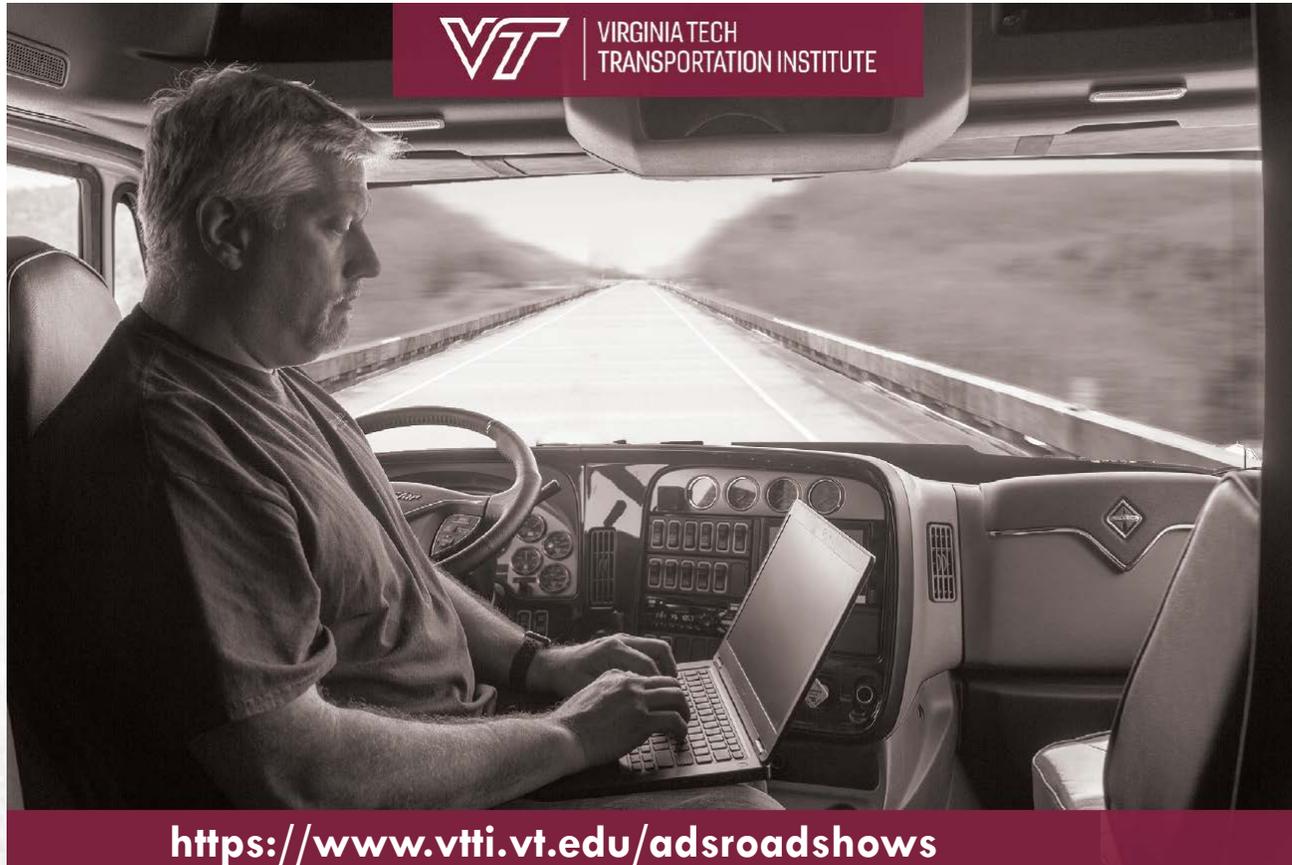


CAMP

CRASH AVOIDANCE METRICS PARTNERS LLC



Automated Trucks and Mixed Fleets



- Provide the trucking industry with clear guidelines on how to safely implement and benefit from trucks equipped with automated driving systems.
- In concert with the development of a fleet concept of operations, demonstrations will occur on public U.S. roadways.



Real World Deployment Considerations

An innovative approach is needed for the deployment of ADSs.

Safety testing alone may not fully ensure safe, robust, and reliable ADS technologies.

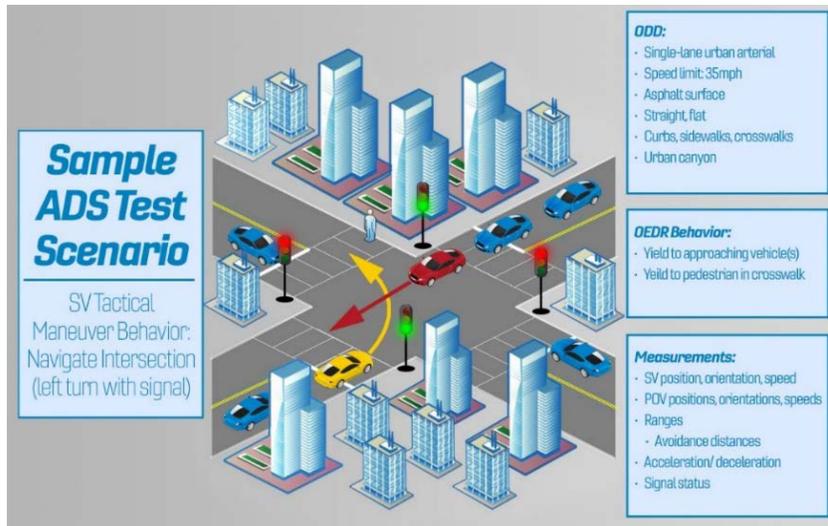
Some examples for manufacturers to consider include:



Development of Safety Testing for ADSs

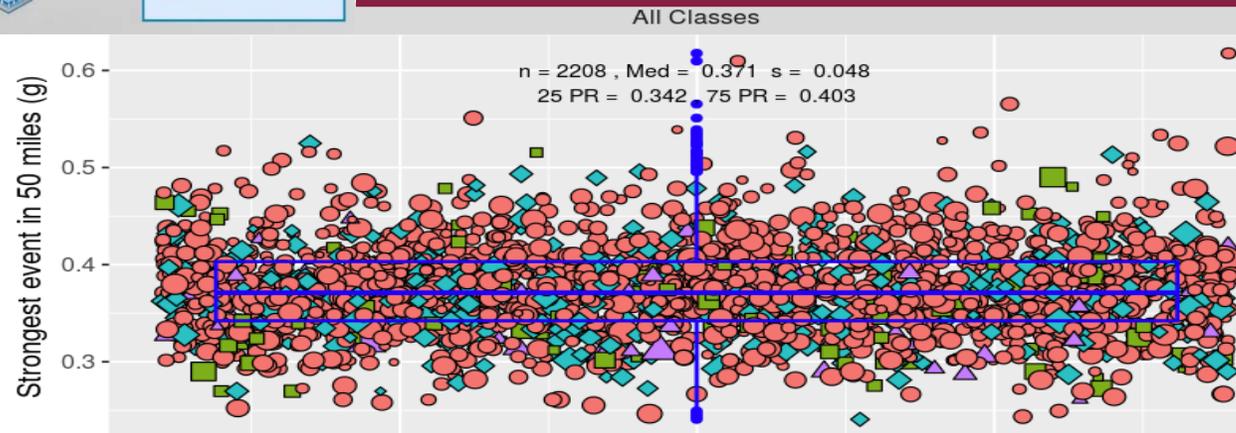
All elements needed for the development of ADS safety testing are in place, but they must evolve rapidly and be universally agreed upon.

Testing Framework



Data and Analysis for Framework Implementation

Real-world Deployment Considerations





Thank You!
どうもありがとう！