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

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Workshop on Consensus Safety Measurement Methodologies for ADS Equipped Vehicles

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The question of "when" ADS technology will be deployed has changed to "where"

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- Technically, most companies are just testing, but…
- This testing involves more than engineers monitoring ADS performance and tracking disengagements:
- **Waymo** launched a driverless service in the **Phoenix** area and is testing in **Kirkland, Atlanta, Detroit, Austin** and multiple areas near **Mountain View**.
- **Ford** is testing pizza delivery in **Miami** with additional testing in **Dearborn, Miami, Pittsburgh, DC** and plans for testing in **Austin**.
- **APTIV** and **Lyft** have a partnership "driving" riders in **Las Vegas**
- **Nuro** is delivering groceries in **Scottsdale**.
- **GM** plans to pilot a food delivery service in **San Francisco** this year with testing also taking place in **Warren** and **Scottsdale**.

Some Milestones in the U.S. Traffic Environment

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1885 First seat belt patent is awarded

1901 First statewide traffic laws enacted in Connecticut

1907 First national road inventory published (for 1904)

1910 First drunk driving laws enacted in New York

1911 First documented use of a painted center line used for road surface marking

1920 Four-way, three-color traffic signal tower, installed at an intersection

1934 First motor vehicle crash test

1938-1940 Pedestrian Walk/Don't Walk Signal

1952 First rumble strips implemented in New Jersey

1953 Motorcycle Helmet developed

1966 First Botts' Dots were installed in California

1967 FMVSS No. 209, Seat Belt Assemblies, was the first FMVSS

1968 First seat belt law

1978 First consumer information program: Frontal Impact Testing

1995 49 of the 50 states have mandatory seatbelt laws

2003 National implementation of the Click It or Ticket seat belt enforcement program

2005 all US States, the District of Columbia, and Puerto Rico have enacted .08 BAC laws

2007 Electronic Stability Control (ESC) mandated on passenger and light-duty vehicles

2011 Updates to Child Safety recommendations to be categorized by age rather than type of child seat.

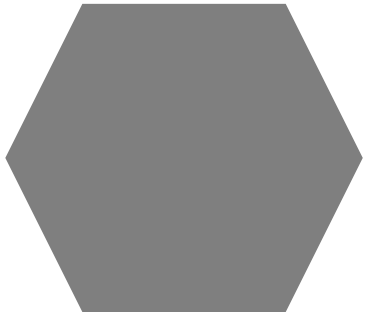
2015 Automated Emergency Braking MOU Signed

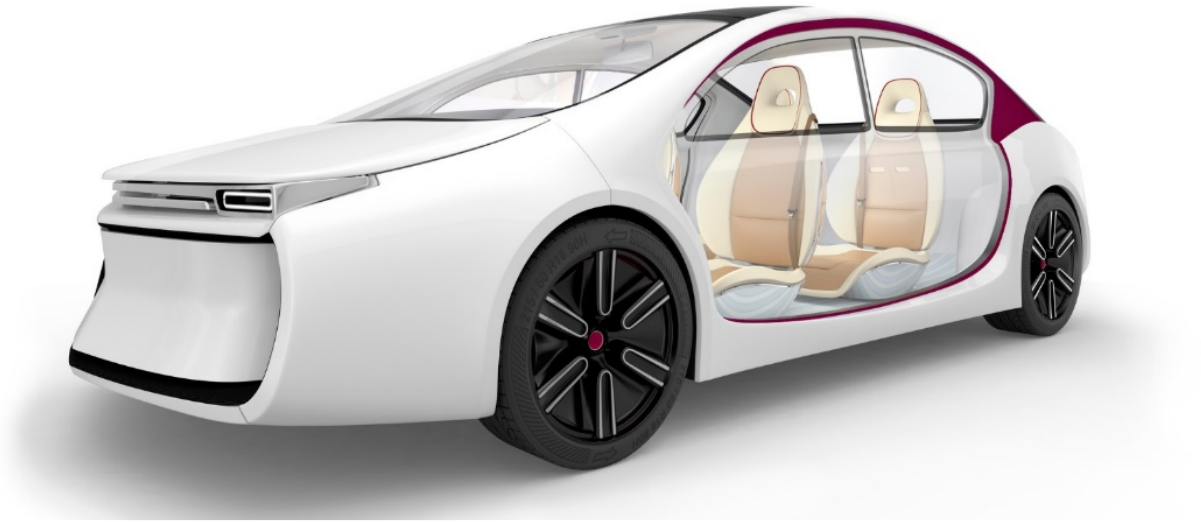
2016 Seat belt use achieved an all-time high rate of 90%

Development of Safety Testing for ADSs

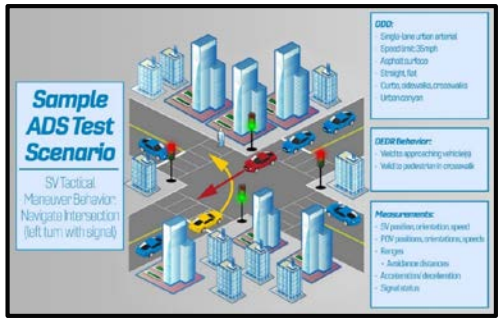
The development of safety testing for ADSs is needed and will not happen overnight

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



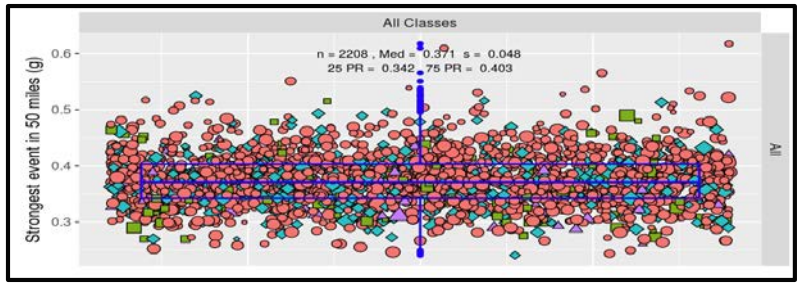


Development of Safety Testing for ADSs



Testing Framework

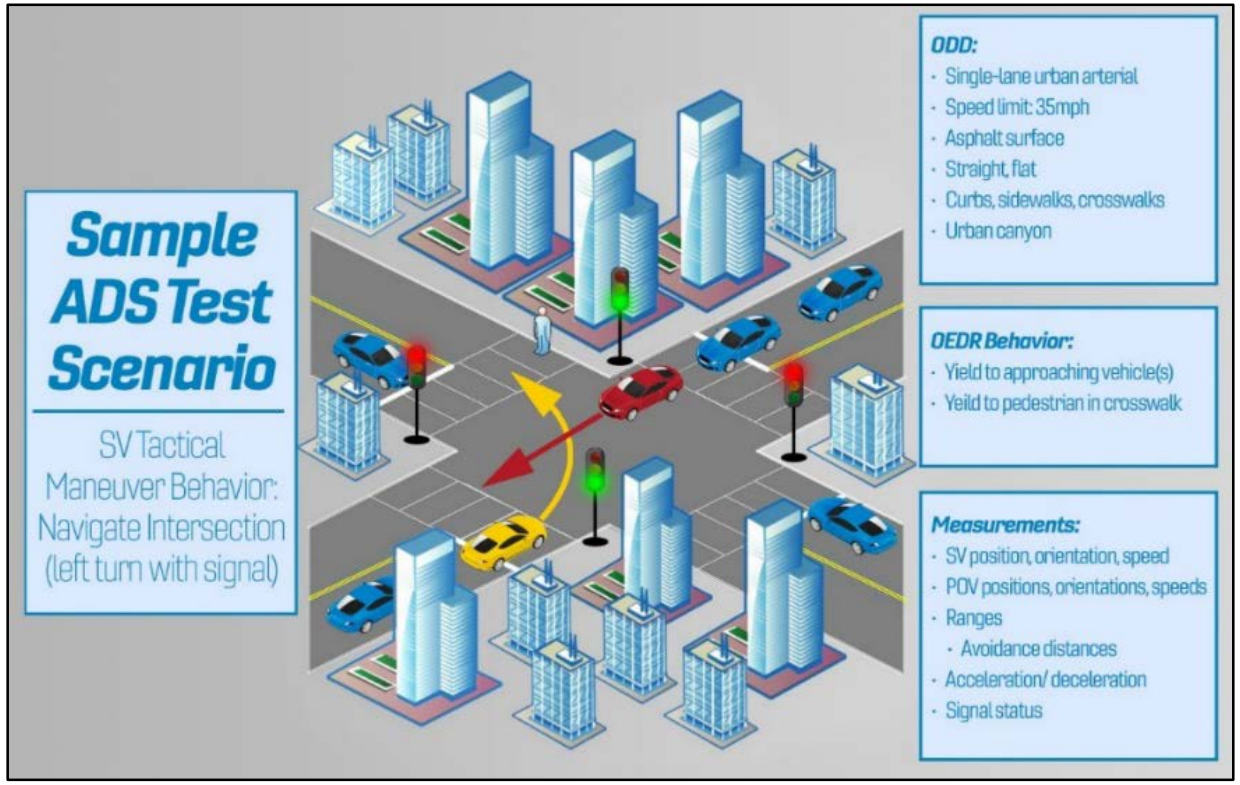
Data and Analysis for Framework Implementation

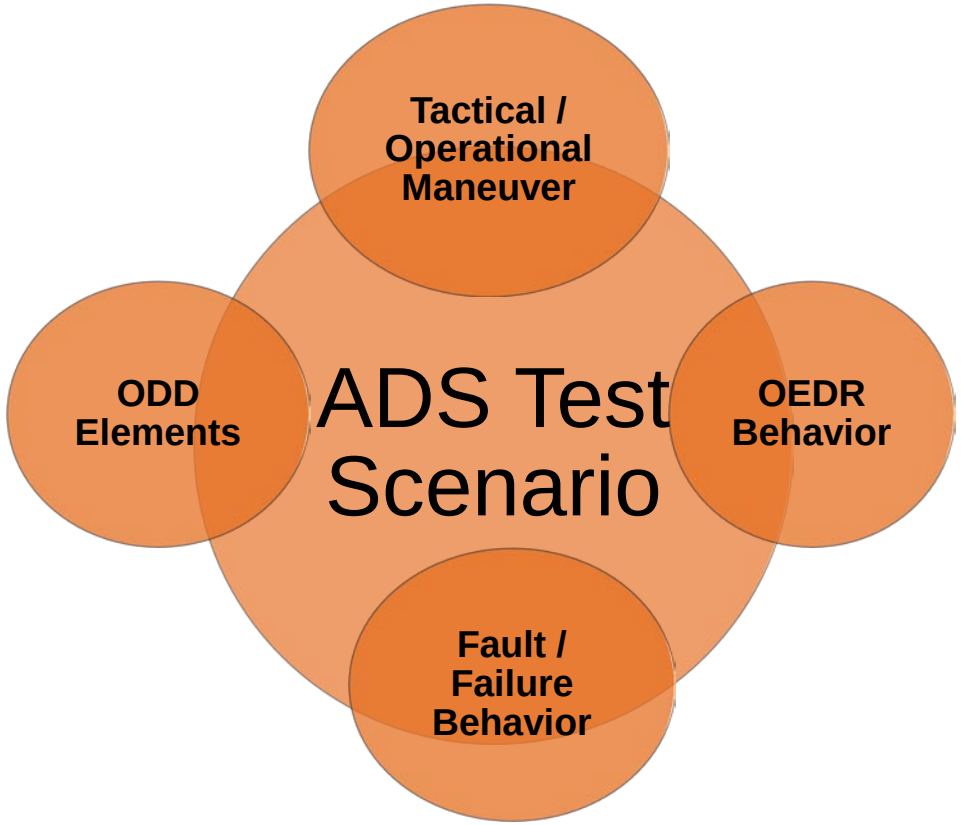


Real-world Deployment Considerations

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.



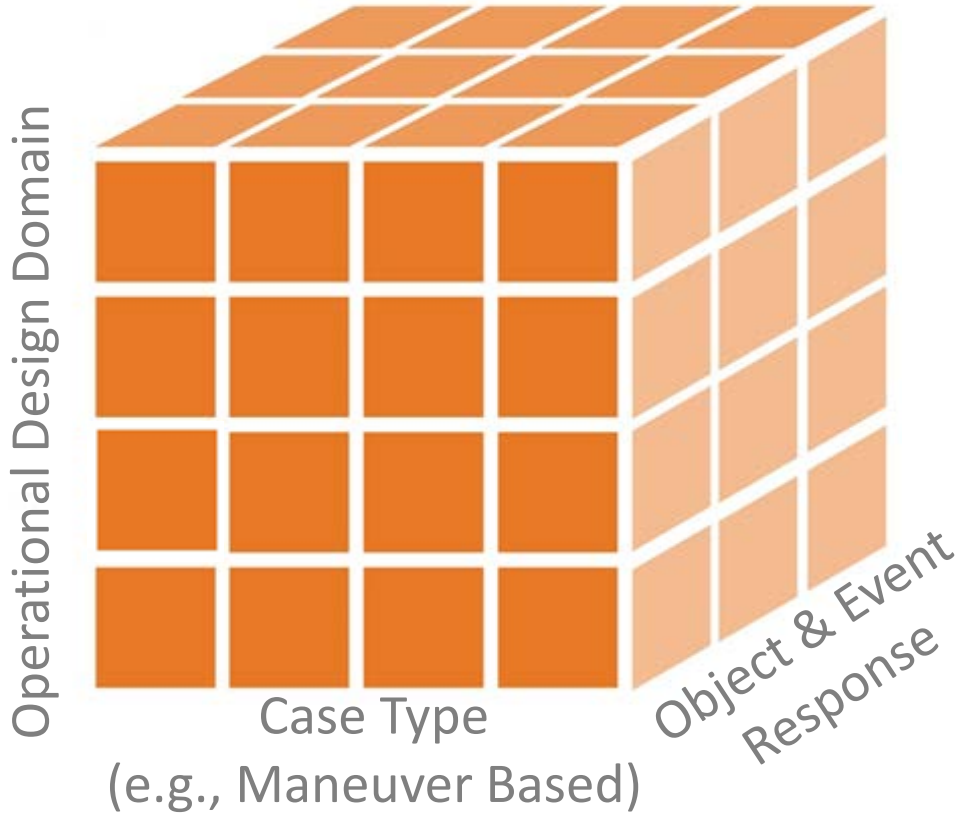


Reference:
Thorn, E., Kimmel, S., and Chaka, M. (2018, September). A framework for automated driving system testable cases and scenarios (Report No. DOT HS 812 623). Washington, DC: National Highway Traffic Safety Administration. URL: https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13882-automateddrivingsystems_092618_v1a_tag.pdf

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.

- Naturalistic Driving Data
- U.S. National Accident Data
- Field Operational Data
- Rules of the Road



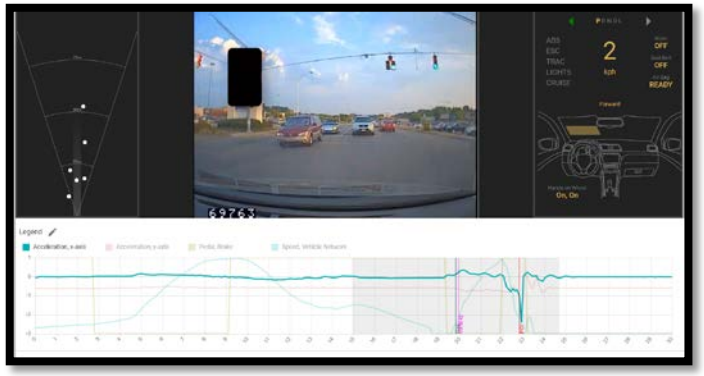
AMP

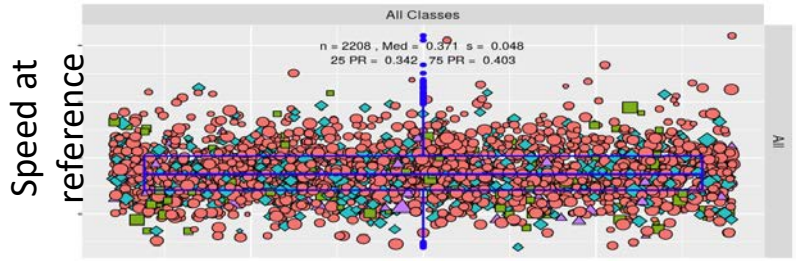
Automated Mobility Partnership

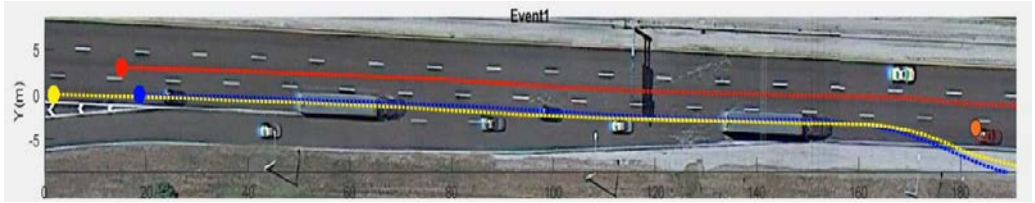
An industry partnership promoting the development of tools, techniques, and data resources to support the rapid advancement of automated-vehicle deployment for its members.

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.







- Library of Cases
- Interactive Analytics
- Case Reconstruction

→ **Tool for the Development and Evaluation of ADSs**

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

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


Surface Street
Reconstruction
VTTI

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

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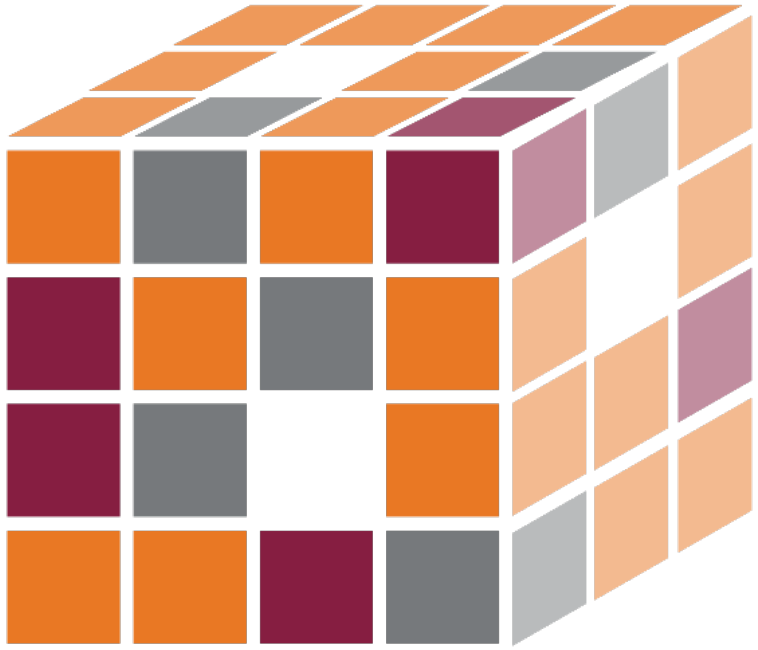
The complexity of the ADS and potential test cases may require a multifaceted testing architecture.



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.

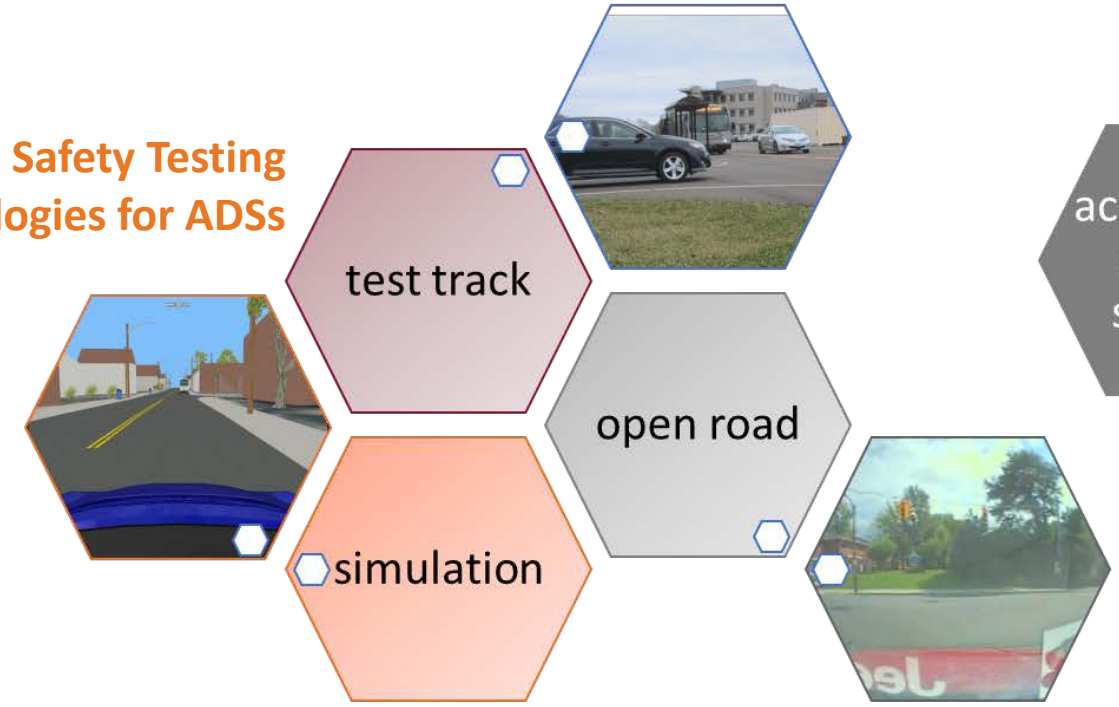
Vulnerable road user interactions add to unpredictability and error severity.

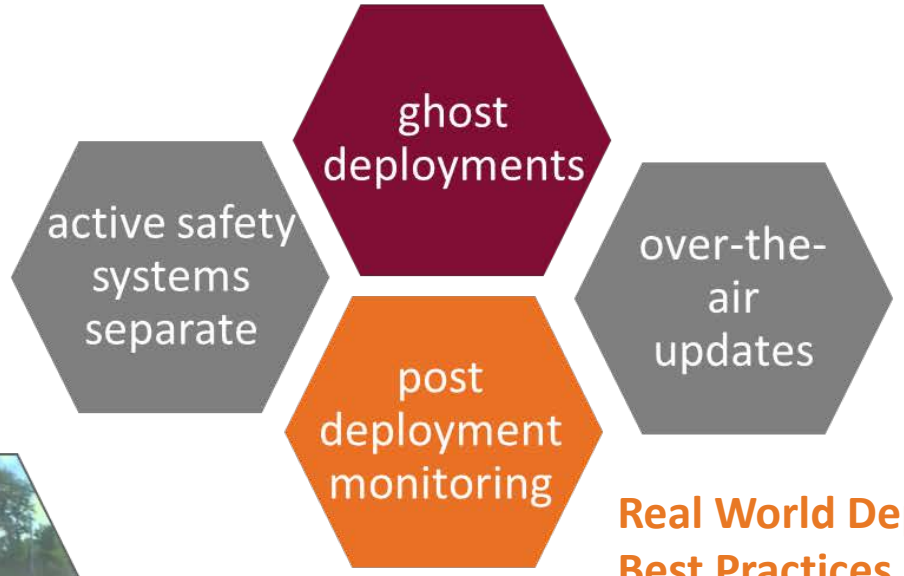
Human drivers, even safe ones, are highly variable.

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:

Safety Testing Methodologies for ADSs

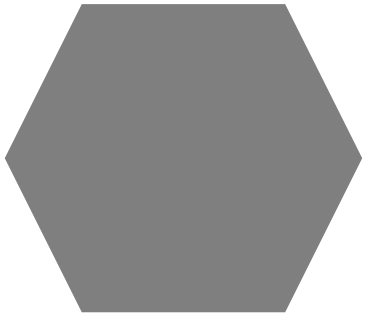




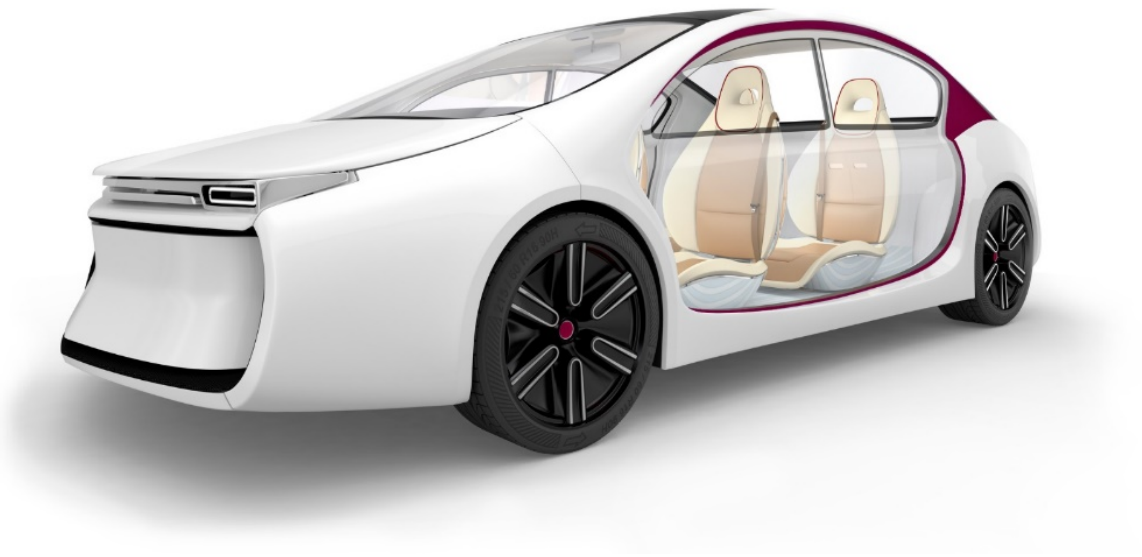
Real World Deployment Best Practices

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.



Progress will occur
one element at a time



Advancing Transportation Through Innovation

Thank you

References for Milestones in the U.S. Traffic Environment

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1885 The First Seat Belt: The first seat belt patent is secured by Edward J Claghorn of New York.

1901 Statewide Traffic Laws: Connecticut creates the first statewide traffic laws. The new laws limit motor vehicle speed to 12 mph in cities and 15 mph on country roads.

1907 First national road inventory published (for 1904).
https://www.fhwa.dot.gov/publications/publicroads/96spring/p96sp44.cfm

1910 Drunk Driving: New York introduces the first drunk driving laws, penalizing drivers for operating a vehicle while under the influence of alcohol.

1911 A painted line along Trenton's River Road in Wayne County, Michigan is the first documented use of a painted center line used for road surface marking
https://en.wikipedia.org/wiki/Edward_N._Hines

In 1920, William Potts designed the first four-way, three-color traffic signal tower, which was installed at the intersection of Woodward and Michigan Avenues in Detroit in October 1920
https://en.wikipedia.org/wiki/William_Potts_(inventor)

1934 General Motors conducts the first vehicle crash test in Milford, Michigan. (barrier test) https://www.titlemax.com/resources/a-chronology-of-car-safety/ and other

1938-1940: Pedestrian Walk/Don't Walk Signal installed at intersection
https://www.fhwa.dot.gov/infrastructure/walk.cfm

1939 Buick introduces electric turn signals, replacing hand signals.
https://www.titlemax.com/resources/a-chronology-of-car-safety/

1952 Rumble strips first implemented on the Garden State Parkway in New Jersey
https://en.wikipedia.org/wiki/Rumble_strip#History

1953: Motorcycle Helmet developed by University of Southern California Professor C.F. Lombard. Designed to absorb the shock of impact. Patent awarded (later?)

1966 the first Botts' Dots were installed on Interstate 80 around Fairfield and on Highway 99 near Fresno (CalTrans)
https://www.snopes.com/fact-check/botts-dots/

1968 First seat belt law required all vehicles (except buses) to be fitted with seat belts in all designated seating positions.
https://en.wikipedia.org/wiki/Seat_belt_laws_in_the_United_States

1978 Frontal Impact Testing: The first consumer information program on vehicle safety is established and a 35 mph frontal crash test is administered.

1995 49 of the 50 states have mandatory seatbelt laws
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2003: The Click It or Ticket seat belt enforcement program goes nantional, working to increase seat belt use in all 50 states.

2005 .08 BAC Laws: By 2005, all US States, the District of Columbia, and Puerto Rico have enacted .08 per se laws.

2007 Electronic Stability Control (ESC) is mandated on all passenger and light-duty vehicles.

2011 Updates to Child Safety recommendations to be categorized by age rather than type of child seat.

2016 Seat belt use achieved an all-time high rate of 90 percent (DOT HS 812 662)

Ref for blue font items: https://one.nhtsa.gov/nhtsa/timeline/index.html