

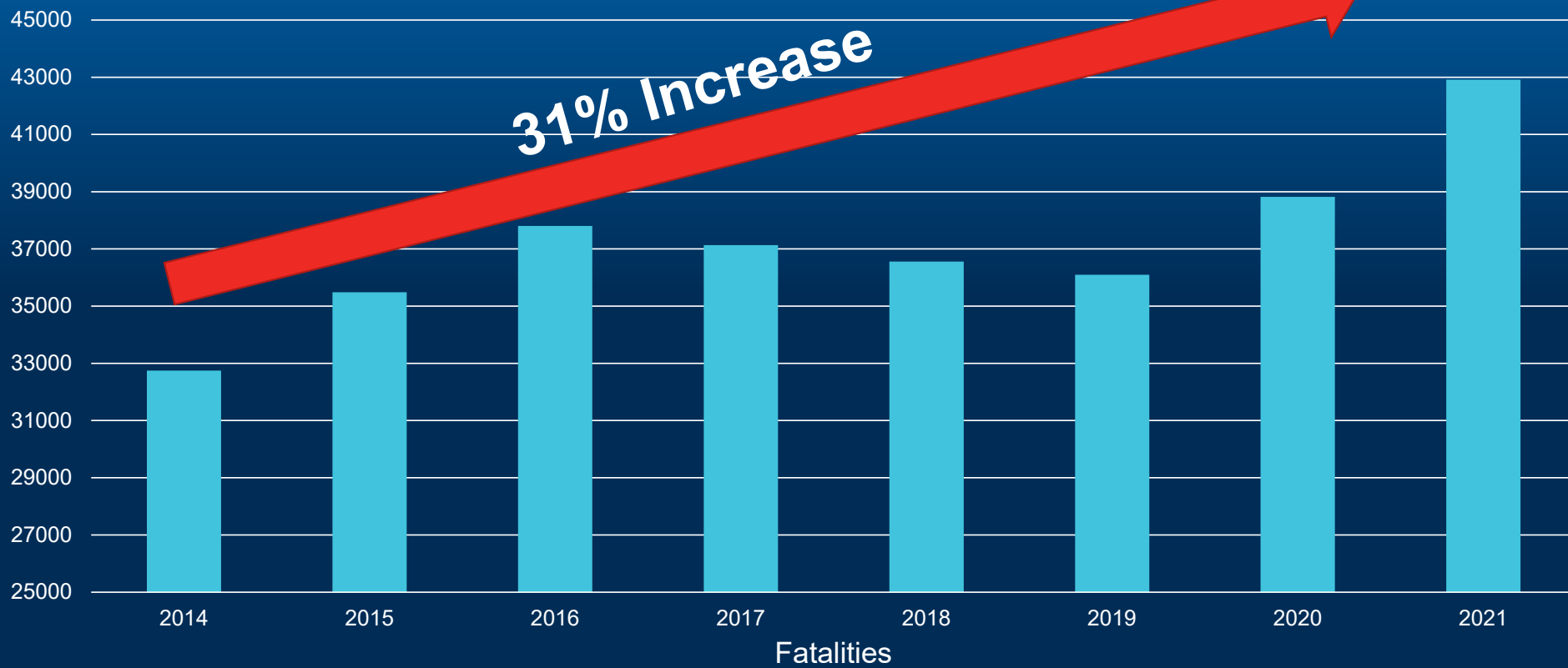


Is Automated Driving Part of a Safe System Approach?

Member Michael Graham

April 3, 2023

United States Roadway Fatalities



Safe System Approach to Roadway Safety



AV Lessons Learned from NTSB Investigations

Limitations of
Onboard Sensors –
Mt. Pleasant, PA

CAS

Automation
Complacency –
Mountain View, CA

L2

Safe Testing of
ADS on Public
Roads –
Tempe, AZ

L4+

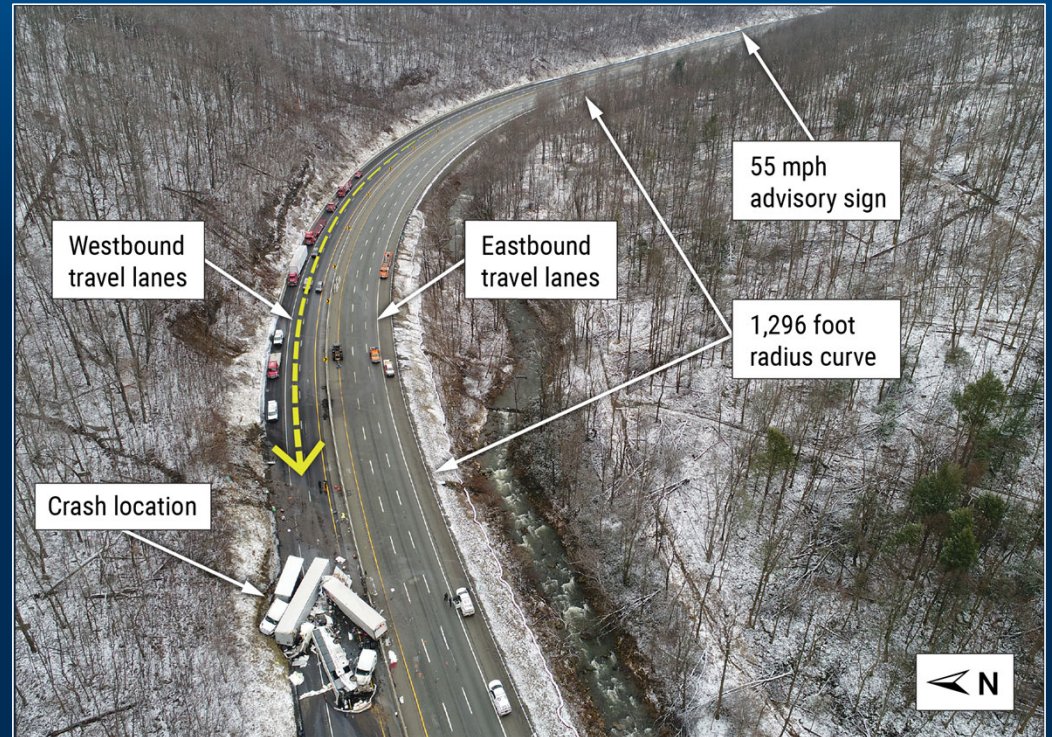


Multivehicle Crash Near Mt. Pleasant Township, Pennsylvania

January 5, 2020

Interstate 70/76 – Mt. Pleasant, PA

- January 5, 2020; 3:30am
- Slight precipitation
- Mountainous interstate curve with 55mph advisory speed
- Motorcoach entered curve at 77mph
- Excessive steering input from motorcoach
- Motorcoach overturned
- Initial position of rest blocked both lanes and shoulders



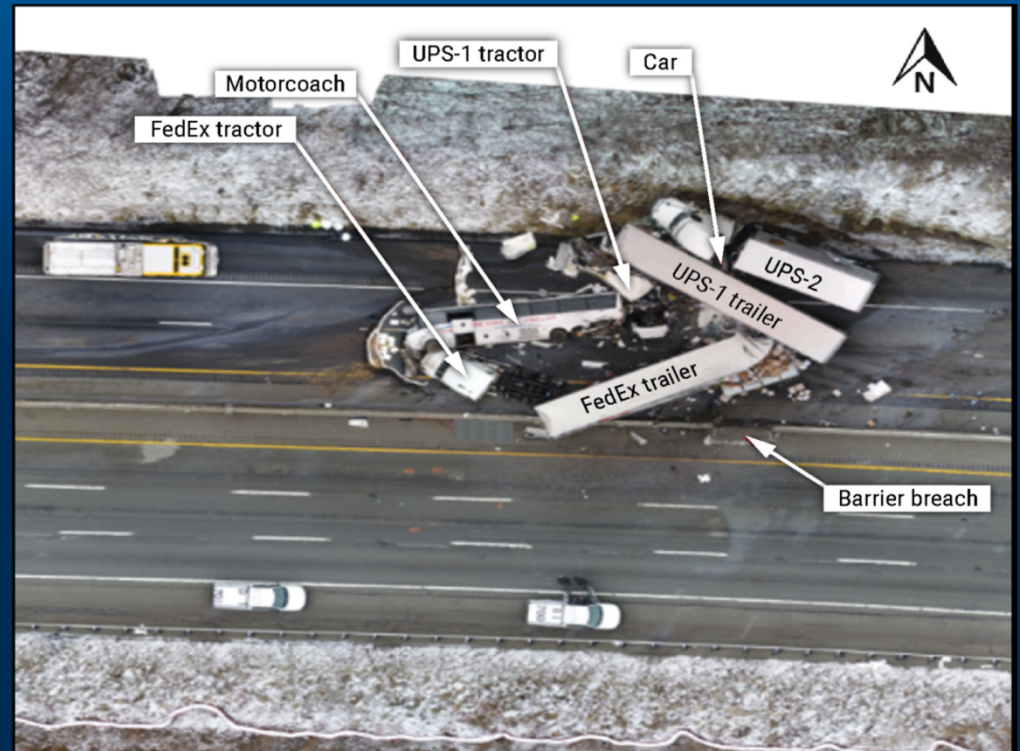
Subsequent Crashes

Vehicles Involved (in order)

- FedEx truck
- UPS truck (UPS-1)
- Car
- UPS truck (UPS-2)

Resulting Injuries

- 5 fatal
- 50 injured



Source: Pennsylvania State Police – NTSB overlay

Collision Avoidance Systems



Source: FedEx forward-facing video, annotated by NTSB

- FedEx-1, UPS-1, and UPS-2 all equipped with Collision Avoidance System –including AEB
- FedEx driver described overturned motorcoach as a “black wall”
- NTSB Finding: Circumstances of the impact for each of the three trucks were likely outside the capabilities of the collision avoidance system on the vehicles

Limitations of Onboard Sensors

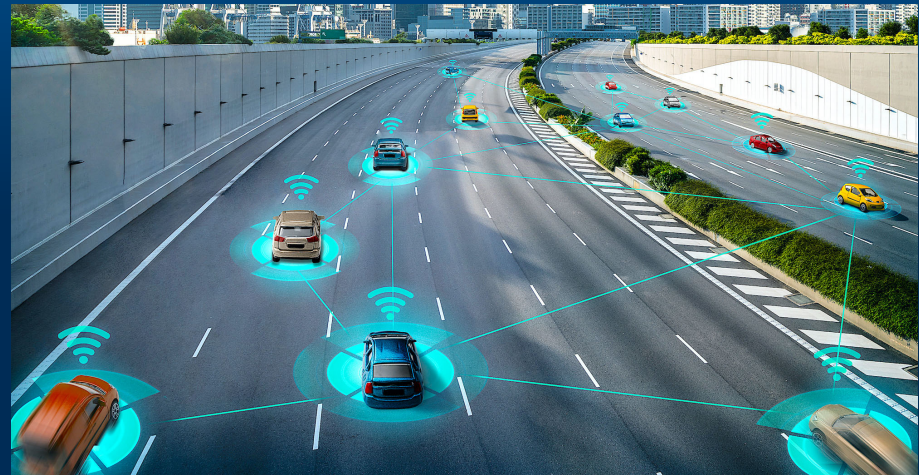
Identified limitations of current onboard line-of-sight sensors in this crash:

- Seeing around a curve or obstacle
- Inclement weather
- Orientation or profile of overturned motorcoach

NTSB Finding: Connected vehicle technology, if installed on the vehicles involved in the crash, could have provided information about the overturned motorcoach in the roadway to the FedEx truck, UPS-1, UPS-2, and the car, so that the drivers could be alerted to the hazard they were approaching, and the automated vehicle systems might have prevented the crashes involving those vehicles

V2X Technology

- Camera, lidar, radar, etc. deployed in vehicles today will be used in AVs
- We must get this right to achieve widespread deployment of AVs
- AV industry so far unable to overcome limitations of onboard sensors
- V2X technology, through direct communication, is not limited by line of sight, inclement weather, or unexpected orientation of a vehicle
- V2X could provide solution for AV industry





Collision Between a Sport Utility Vehicle Operating with Partial Automation and a Crash Attenuator

Mountain View, CA

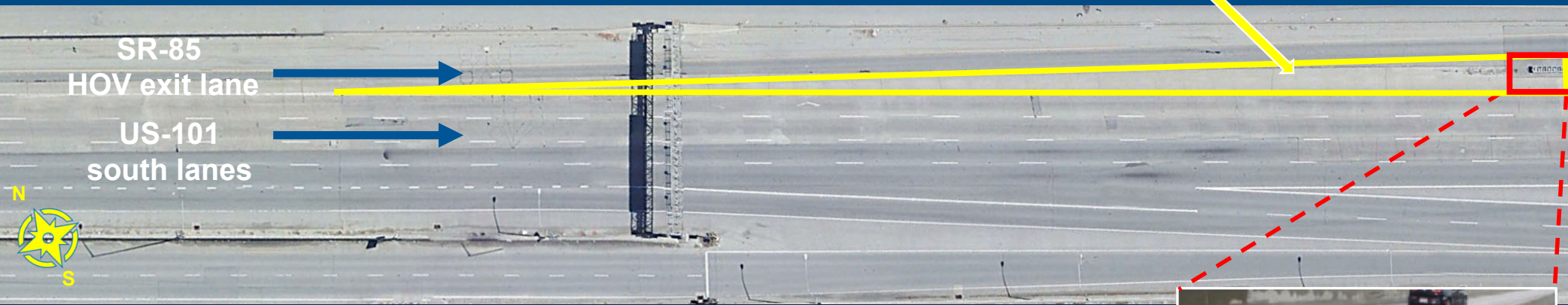
March 23, 2018

Crash Overview

- Friday, March 23, 2018
- 9:27 a.m.
- Mountain View, California
- US-101 / SR-85 interchange
- 2017 Tesla Model X SUV
- 38-year-old driver
- Partial automation “Autopilot” engaged



Crash Sequence

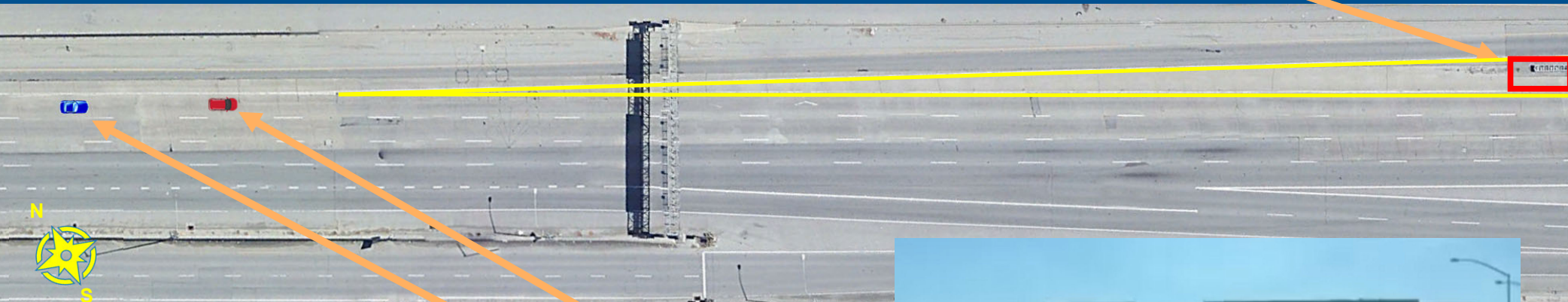




Crash attenuator was collapsed and nonoperational prior to the crash



Crash Sequence

Crash attenuator



-  — Tesla
-  — Lead vehicle

Lead vehicle

Time to crash: 7.9 seconds
Speed: 64.3 mph
Lead vehicle: 83.7 feet
Distance to crash: 748 feet



Crash Sequence

Crash attenuator



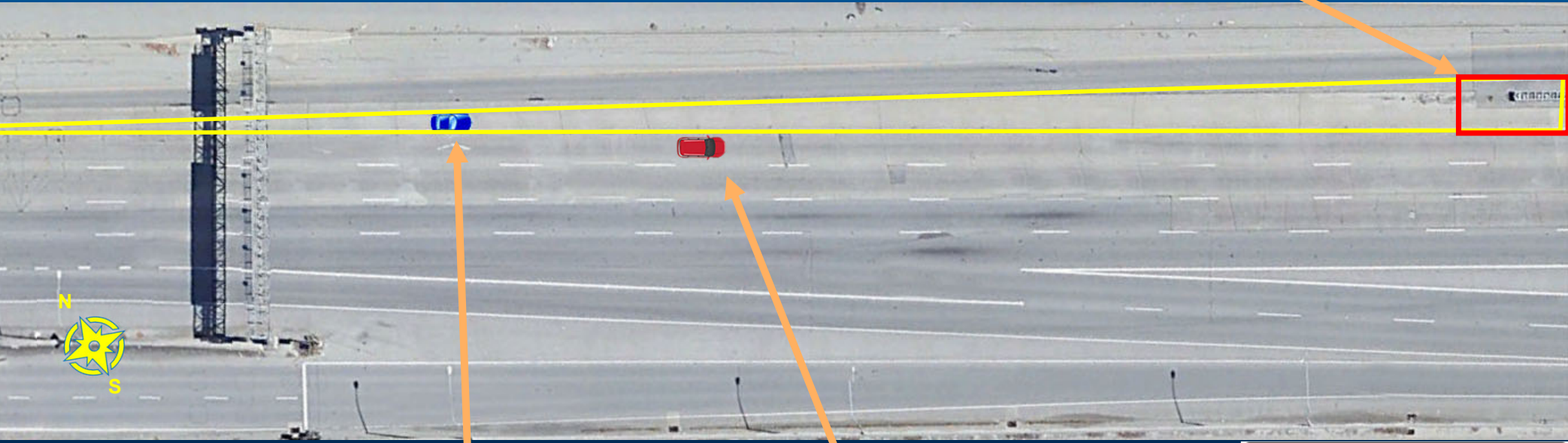
Time to crash:	5.9 seconds
Steering:	5.6 degrees left
Speed:	64.1 mph
Lead vehicle:	82 feet
Distance to crash:	560 feet
Indication:	Hands-off steering wheel

Lead vehicle

	—	Tesla
	—	Lead vehicle



Crash Sequence

Crash attenuator

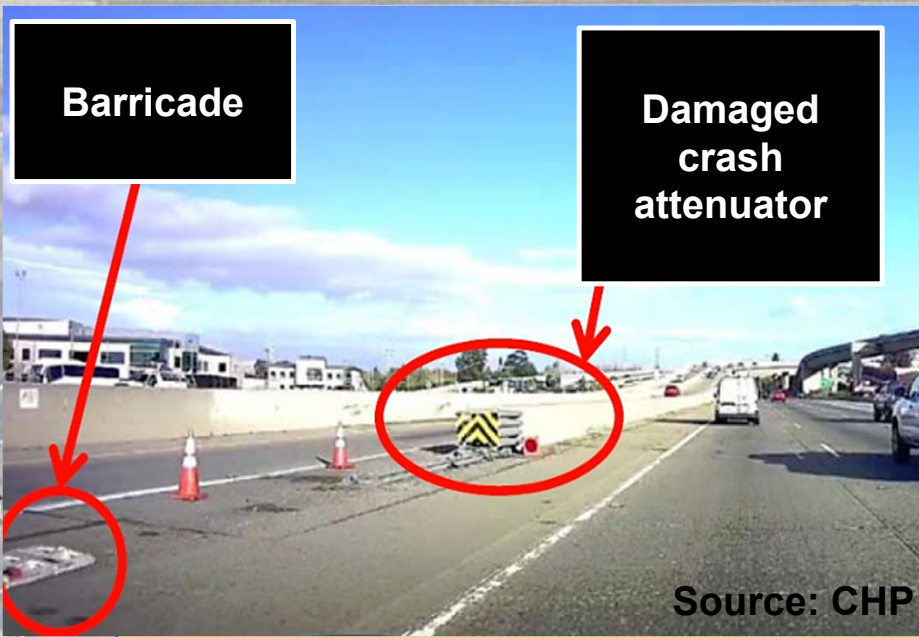


Time to crash: 3.9 seconds
Speed: 61.9 mph
Lead vehicle: None detected
Distance to crash: 375 feet
Vehicle begins to accelerate
Hands-off steering wheel indicated

Lead vehicle
(no longer followed)

	—	Tesla
	—	Lead vehicle

Crash Sequence



Barricade

Damaged crash attenuator

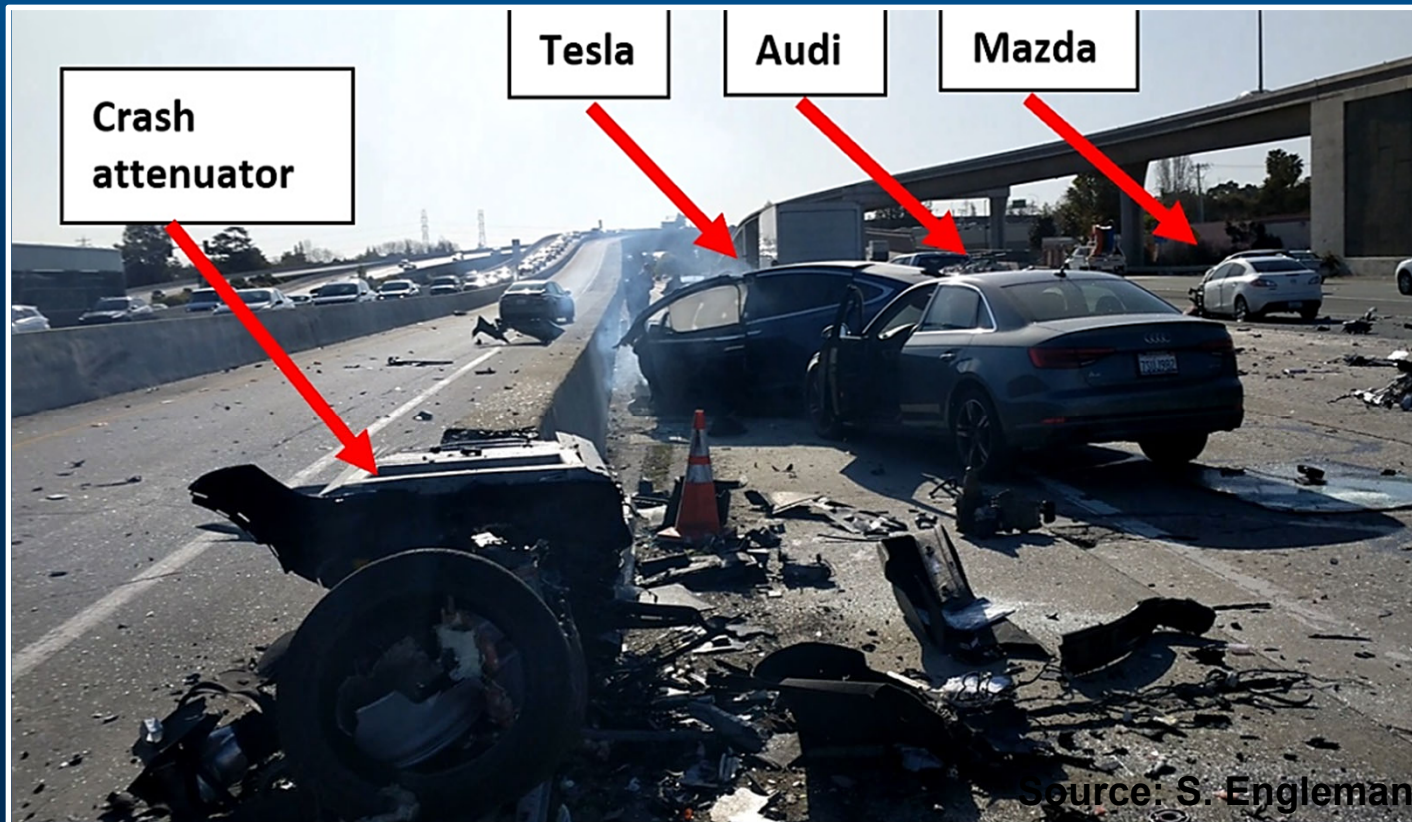
Source: CHP

Barricade and cones placed in advance of attenuator prior to crash



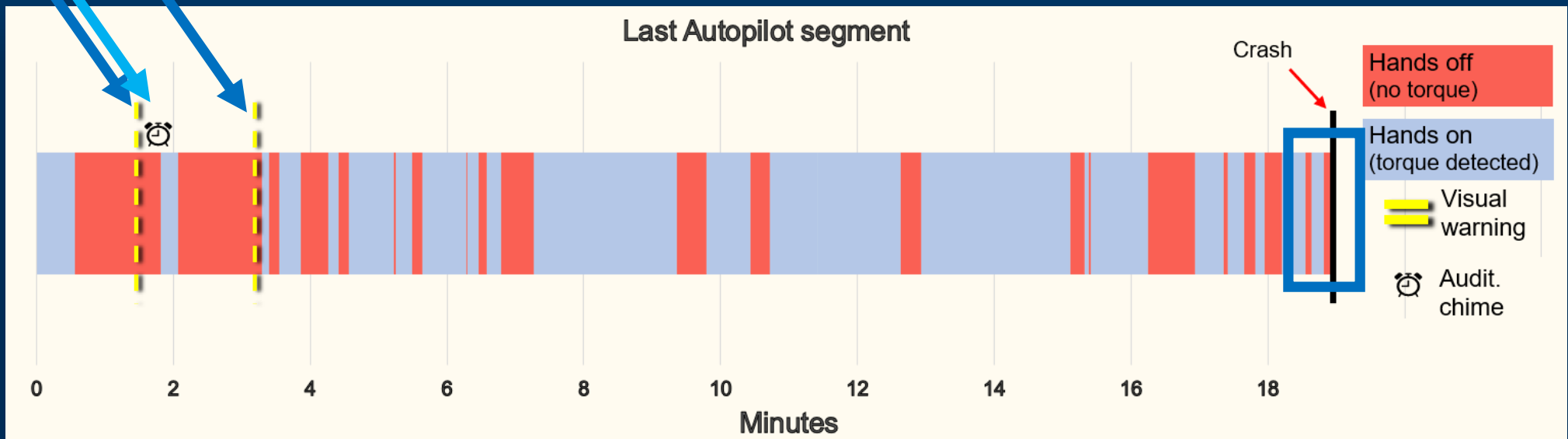
Impact speed: 70.8 mph

Crash Sequence



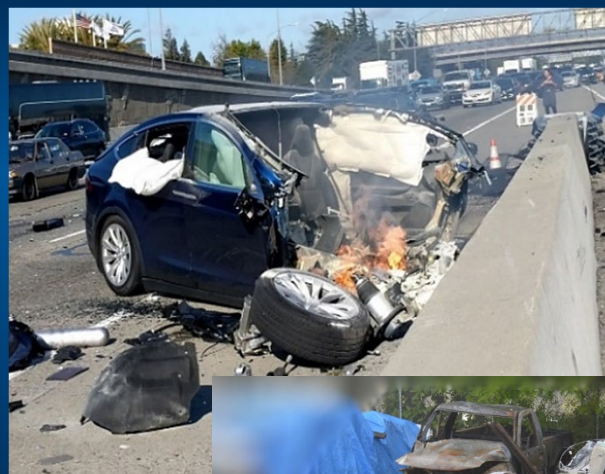
Driver Engagement

- The crash trip lasted 28.5 minutes
- Lack of response awareness, indicated by distraction and overreliance on automation
- Autopilot was engaged for the last nearly 19 minutes



Overreliance on Automation

- Circumstances in Mountainview similar to those of other Level 2 crashes: Williston and Delray Beach, FL; Culver City, CA
- Driver-applied steering wheel torque not detected at time of impact –suggesting driver not engaged
- Prolonged inattentiveness by drivers
- Drivers were ineffective monitors
- Humans are poor monitors of automation
- An engaged driver remains a critical component even with advanced driver assistance systems



Probable Cause

Probable Cause: The National Transportation Safety Board determines that the probable cause of the Mountain View, California, crash was the Tesla Autopilot system steering the sport utility vehicle into a highway gore area due to system limitations, and the driver's lack of response due to distraction likely from a cell phone game application and overreliance on the Autopilot partial driving automation system. Contributing to the crash was the Tesla vehicle's ineffective monitoring of driver engagement, which facilitated the driver's complacency and inattentiveness...

Overreliance on Automation Recommendations

Recommendation to NHTSA and SAE: Develop performance standards for driver monitoring systems that will minimize driver disengagement, prevent automation complacency, and account for foreseeable misuse of the automation (H-20-3)

Recommendation to NHTSA: After developing the performance standards for driver monitoring systems recommended in Safety Recommendation H-20-3, require that all new passenger vehicles with Level 2 automation be equipped with a driver monitoring system that meets these standards. (H-20-4)

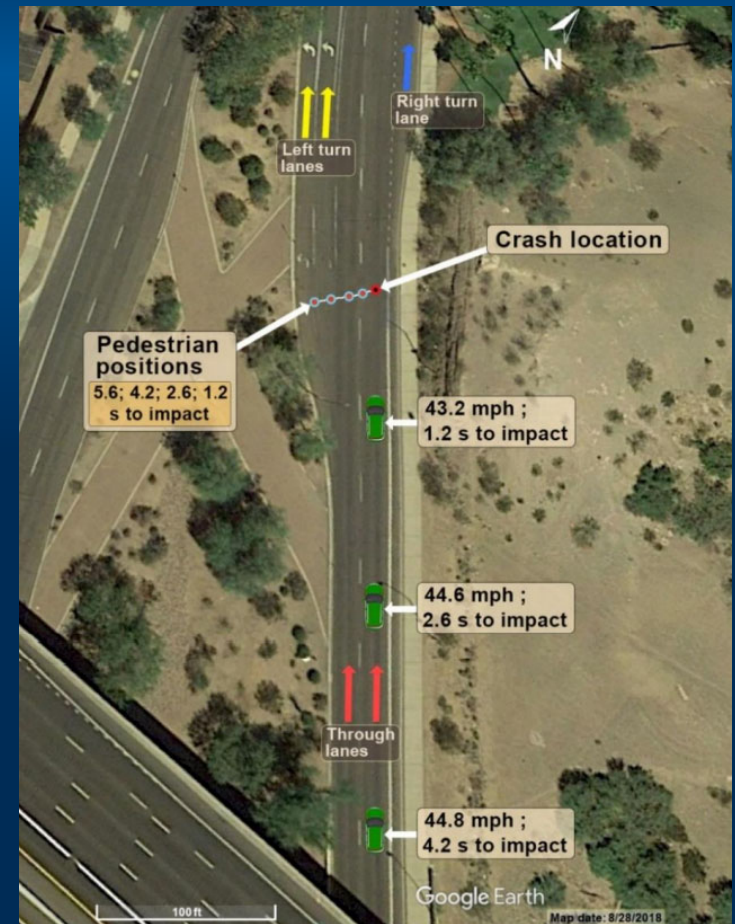


Collision Between Vehicle Controlled by Developmental Automated Driving System and Pedestrian

Tempe, Arizona
March 18, 2018

Sequence of Events

- 3/18/18, 9:58pm
- 2017 Volvo XC90 SUV operating as an ADS test vehicle
- Operator in driver's seat of SUV monitoring ADS
- Pedestrian crossing street not at designated cross walk while pushing a bicycle
- Pedestrian struck by SUV and fatally injured



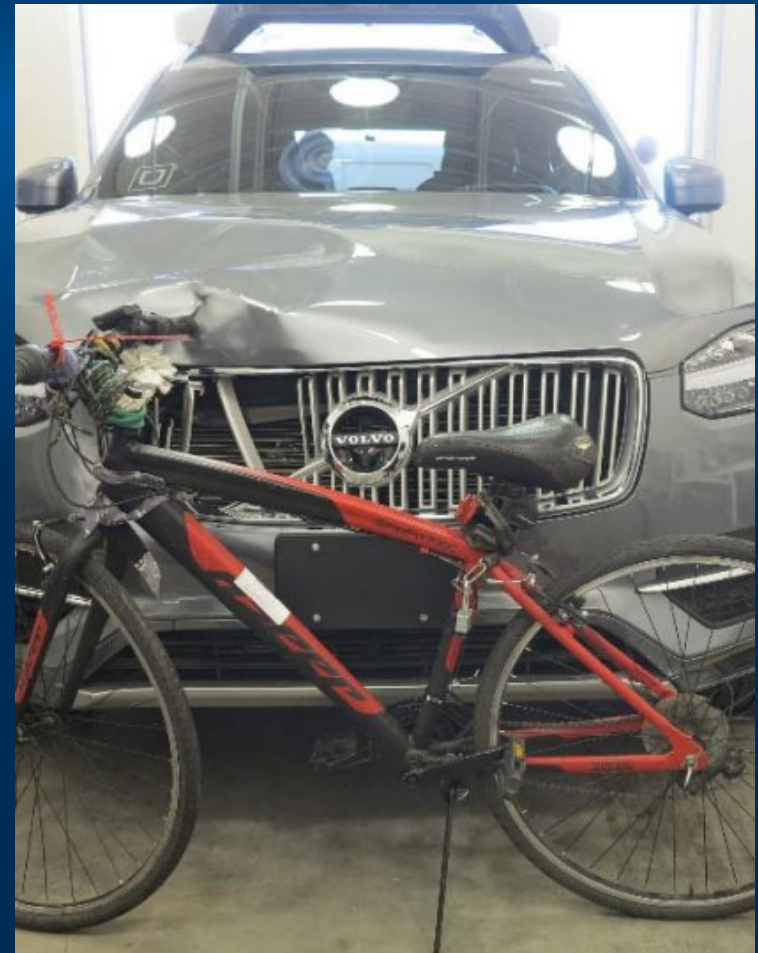
Operator Oversight

Inadequate Safety Culture:

- Individual monitoring SUV watching TV on her for phone for 1/3 of the trip and 5 of the final 6 seconds before impact
- Organization did not review in-ward facing camera nor detect violation of cell phone policy
- No safety division or safety manager
- No corporate safety plan

Finding: The Uber Advanced Technologies Group's inadequate safety culture created conditions— including inadequate oversight of vehicle operators—that contributed to the circumstances of the crash and specifically to the vehicle operator's extended distraction during the crash trip.

Recommendation to Uber ATG: Complete the implementation of a safety management system for automated driving system testing that, at a minimum, includes safety policy, safety risk management, safety assurance, and safety promotion. (H-19-52)



Federal Oversight

Finding: Mandatory submission of safety self-assessment reports—which are currently voluntary—and their evaluation by the National Highway Traffic Safety Administration would provide a uniform, minimal level of assessment that could aid states with legislation pertaining to the testing of automated vehicles.

Recommendation to NHTSA: Require entities who are testing or who intend to test a developmental automated driving system on public roads to submit a safety self-assessment report to your agency. (H-19-47)

Recommendation to NHTSA: Establish a process for the ongoing evaluation of the safety self-assessment reports as required in Safety Recommendation H-19-47 and determine whether the plans include appropriate safeguards for testing a developmental automated driving system on public roads, including adequate monitoring of vehicle operator engagement, if applicable (H-19-48)

State Oversight

- Arizona Executive Order 2018-04
 - Testing AVs without Operator Inside – Must acknowledge in writing testing met basic requirements
 - Testing AVs with Operator Inside – No AV specific requirements
 - Uber ATG Tested with Operator Inside – Did not submit any statement or application to ADOT

Finding: Arizona's lack of a safety-focused application-approval process for ADS testing at the time of the crash, and its inaction in developing such a process since the crash, demonstrate the state's shortcomings in improving the safety of ADS testing and safeguarding the public

Recommendation to Arizona: Require developers to submit an application for testing ADS-equipped vehicles that, at a minimum, details a plan to manage the risk associated with crashes and operator inattentiveness and establishes countermeasures to prevent crashes or mitigate crash severity within the ADS testing parameters (H-19-49)

AV Lessons Learned from NTSB Investigations

Limitations of
Onboard Sensors –
Mt. Pleasant, PA

CAS

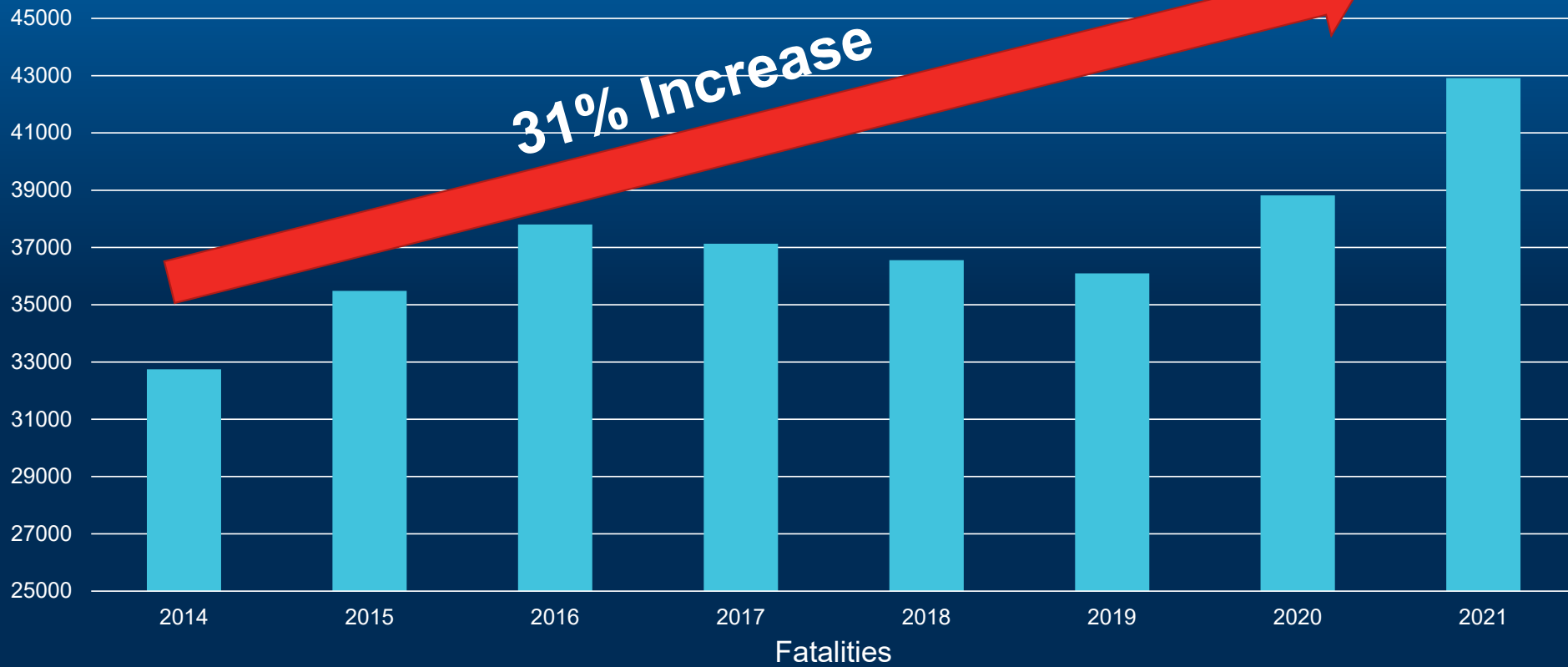
Automation
Complacency –
Mountain View, CA

L2

Safe Testing of
ADS on Public
Roads –
Tempe, AZ

L4+

United States Roadway Fatalities



Connect With the NTSB



@NTSB



@MikeGrahamNTSB



@NTSBgov



NTSB Podcast



@NTSBgov



NTSB Blog – Safety Compass



[linkedin.com/company/NTSB](https://www.linkedin.com/company/NTSB)



[youtube.com/user/NTSBgov](https://www.youtube.com/user/NTSBgov)



[ntsb.gov](https://www.ntsb.gov)