Large-Scale Telematics-Based L2 Super Cruise Field Evaluation

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Field Study Overview (Presentation discusses Study 1 findings)

Objectives & Method	Study 1 – Fleets & Data
• Use OnStar telematics to capture targeted high-priority data from large fleets of vehicles in daily operation • Characterize the SAE level 2 Super Cruise in terms of real-world usage and safety-related metrics. • Similarly analyze camera-based Front Automatic Braking feature.	• 2636 Super-Cruise (SC) equipped MY18-19 Cadillac CT6s • 1175 baseline MY17-19 CT6s without SC; equipped with fusion-based ACC • 4965 GM vehicles with camera-based Front Pedestrian Braking (FPB) and Automatic Emergency Braking (AEB)

### Study 2
Launched with MY21 SC vehicles

Phase III: Super Cruise Overview

- Hands-free advanced driver assistance system (ADAS) technology on compatible roads where engineers have mapped roads
  - Study 1 analysis uses original limited access freeway mapping

- A camera-based Driver Attention System (DAS) is used to understand driver attention to the road ahead and readiness to take control.

- When the DAS detects a driver is not paying attention to the road ahead while in Super Cruise, a series of escalating prompts alert the driver.

- A steering wheel light-bar is used to communicate system/DAS status, along with other alerts and displays.

- Various sources of information detect vehicle position:
  - Precision LiDAR map data detect specific details for upcoming events like corners and exits.
  - Real-time cameras detect lane-lines and vehicle's lane position
  - GPS detects the precise position of the vehicle.

- Only if the GPS places the vehicle on a Super Cruise compatible road, will the driver be able to enable Super Cruise.

- Dedicated customer website → _www.cadillacsupercruise.com_

- Smart Phone MyCadillac App customer-education animation

DRIVER ATTENTION SYSTEM ESCALATION
_PROGRESSIVE SERIES OF WARNINGS AND ACTIONS_
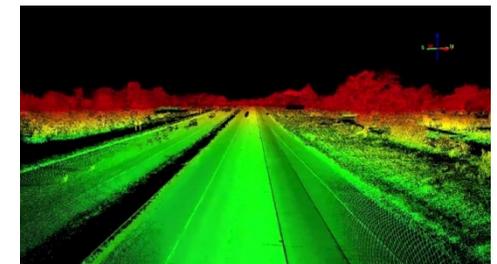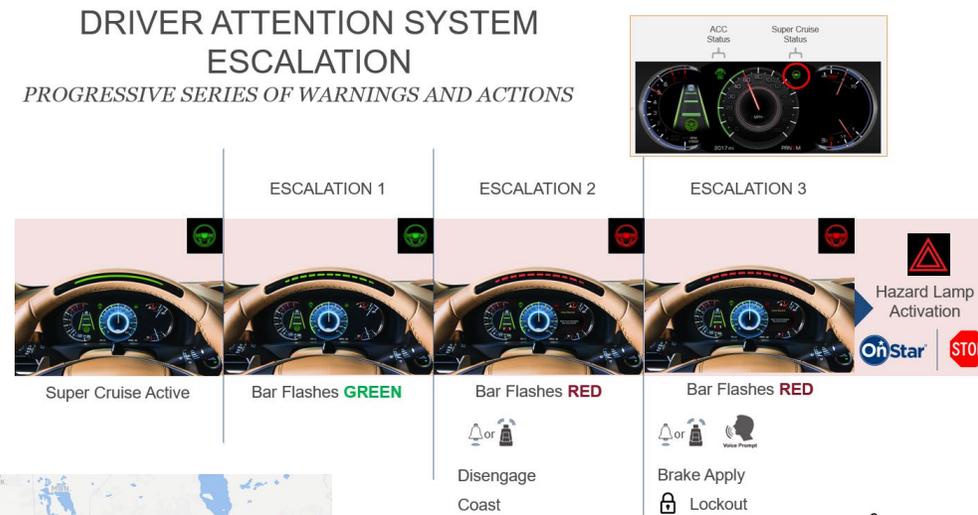
Overall Usage of Super Cruise (SC)

- 14 months of data collection
- 75% of 2642 SC-equipped vehicles engaged SC at least once
- 304,376 separate SC engagements
- 1.7M miles with SC engaged
- No AACN events with SC engaged or during motorway travel for 2 SC fleets

Vehicles
- 750
- 500
- 250

Vehicle locations
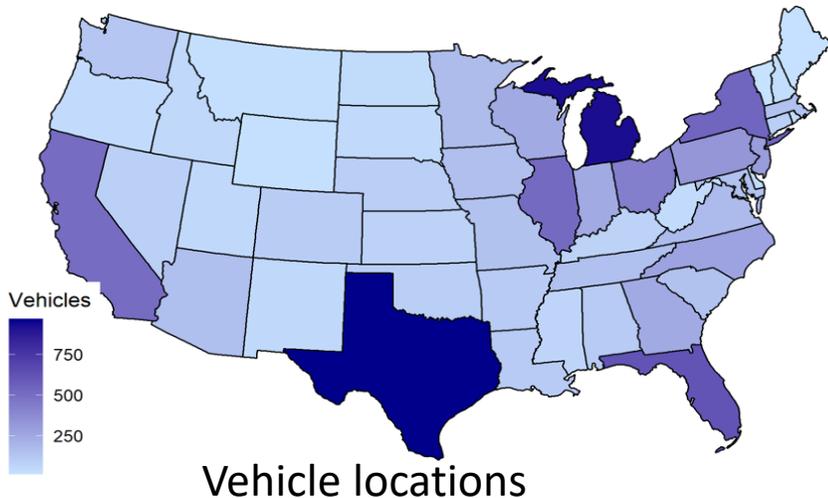
Percent of Motorway Distance in Various System States

Ready 23%

Engaged 18%

Other 1%

Not Ready 58%

OverRide 1%

Degraded 0%

SC engaged for 45% of the total distance when the system is "Ready"

On SC-compatible roads, driver has not enabled ACC, or met various "Ready" conditions for use
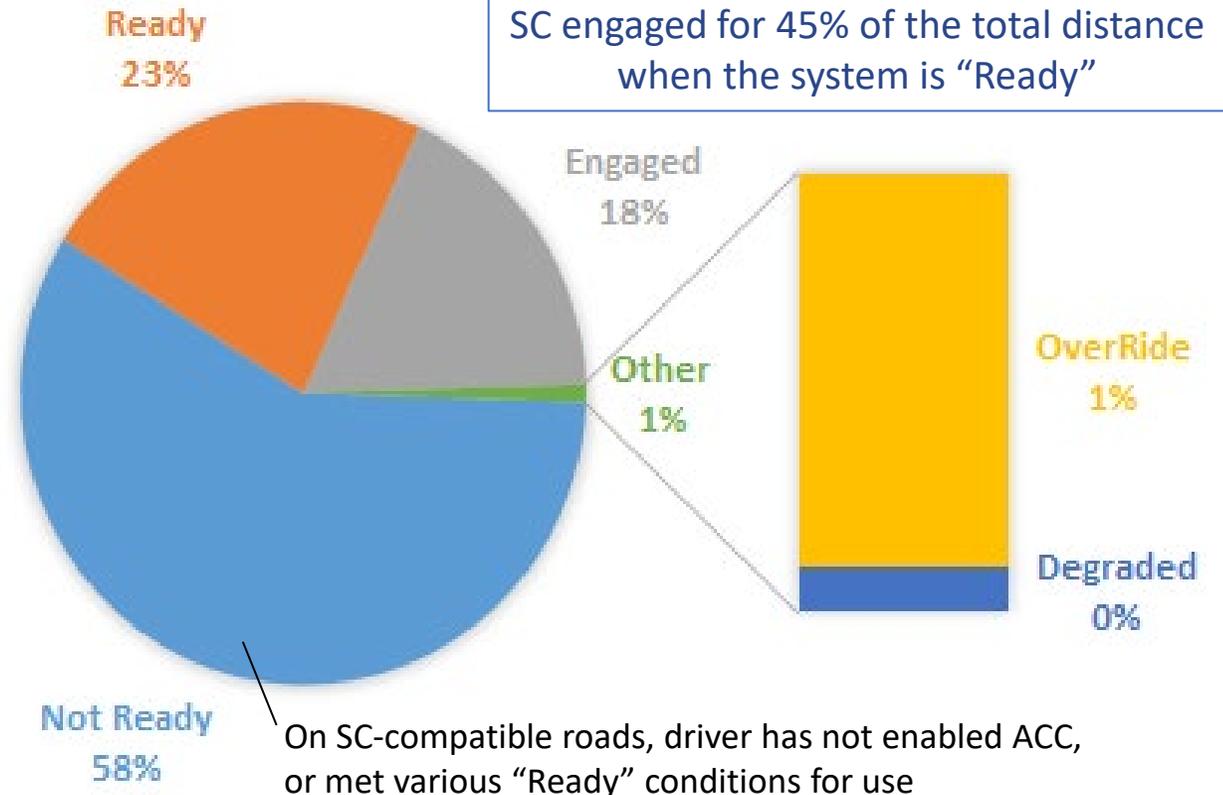
35% of vehicles had Super Cruise engaged during at least 25% of their motorway travel.

Driving Environment Influences SC Usage Rate

Relative to manual driving on motorways, there are marked changes in the proportion of SC driving (which mirror ACC usage patterns)

ACC or SC are used more often	Odds Ratios (OR) (More likely if OR > 1)	
	ACC (vs. Manual)	Super Cruise (vs. Manual)
In free-flow (vs. not free-flow)	4.36	6.87
In non-urban situations (vs. fully urban)	2.00	1.96
At night (vs. daytime)	1.32	1.45
In non-rain conditions (vs. rain)	1.15	1.35
In straight or low-curvature road segments (vs. higher-curvature segments)	1.28	1.47

e.g., Ratio of Super Cruise usage to manual driving usage is higher in free-flow conditions than in non-free-flow.

Speeds When Using Super Cruise

Free-flow conditions are when the minimum speed on the segment never falls <5 MPH below speed limit

In free-flow conditions:

- SC median speeds* were nearly identical (+0.1 MPH) to manual driving, and max speeds were lower (-1.1 MPH).

- Free-flow is dominant SC use case

- ACC-only has similar trends.

In non-free-flow conditions:

- SC median speeds are 2.0 MPH higher than manual, and max speeds were 0.8 MPH higher than manual.

- ACC has similar trends.

- Given other findings, this may be due to selective use of SC in less-hindered traffic.
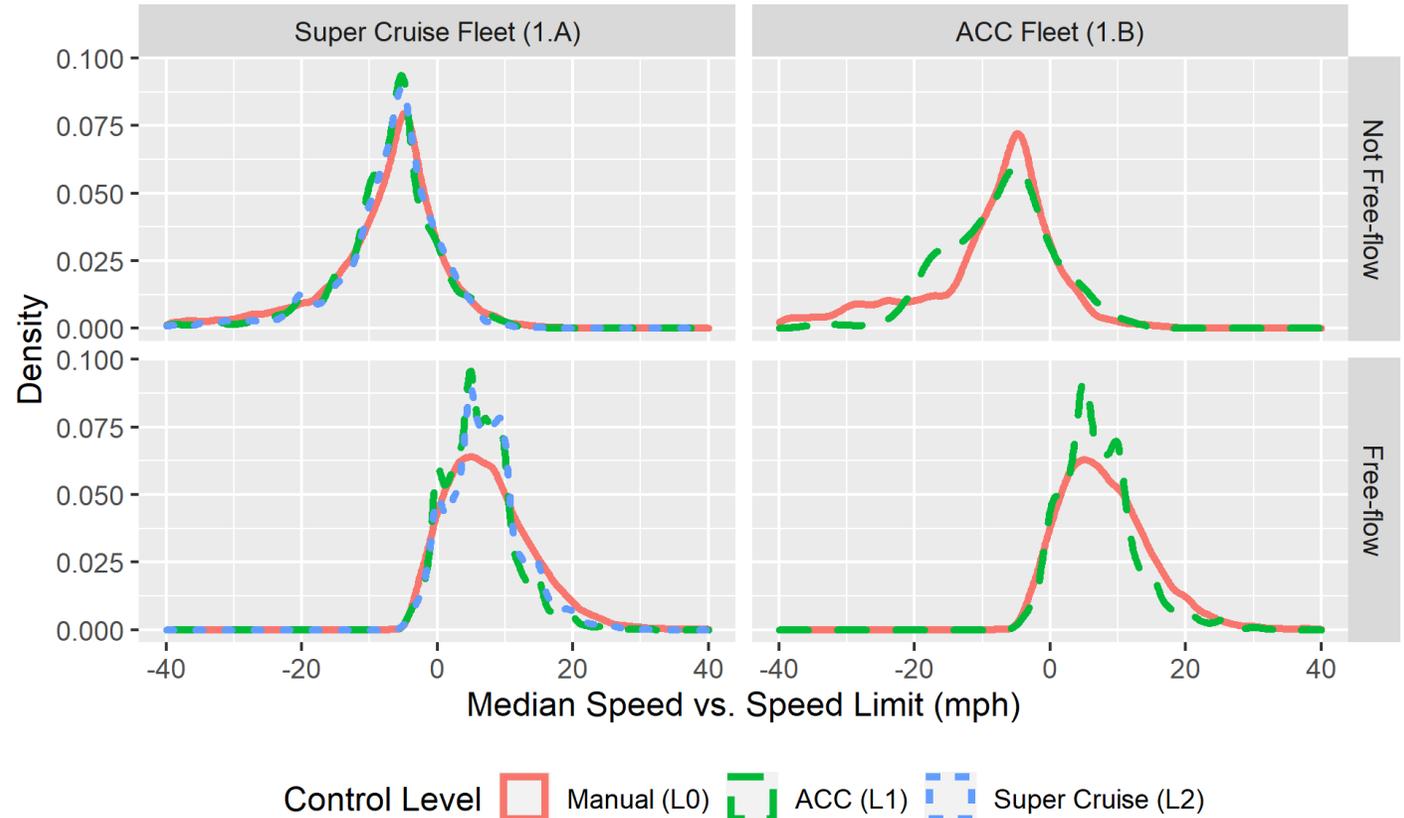

Speeds Relative to Posted Speeds

* Comparisons made based on matched road segments with additional matching or compensation for vehicle, time of day, weekend vs. weekday.

Decelerations When Using Super Cruise

Among the analyses using deceleration as a measure of interest:

- For >9000 "matched" driving passes, vehicles were 1.7 times more likely to exceed 2.6 m/s2 deceleration in manual/ACC versus SC engaged driving (Odds ration =0.58, Confidence interval =[0.44,0.76]).*

  - (This finding is not impacted by presence of free-flow traffic)

- This particular analysis does not address decelerations after the end of an engagement, but other analyses are being performed.
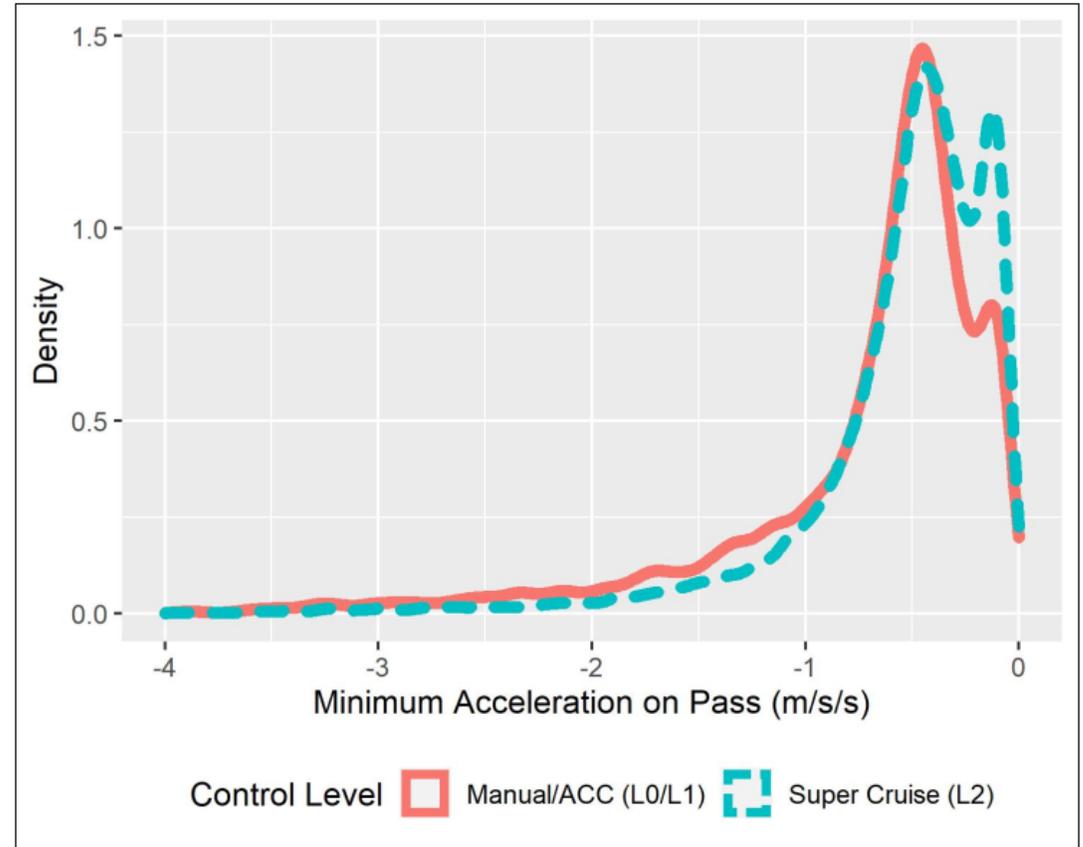
Matched on vehicle, road segments, time of day, weekday, and free-flow conditions.

SC Engagements: Durations and Events within Engagements

Steering over-ride

- Overall <u>median distance</u> of SC engagement events was 2.7 miles, with an 85th percentile of 10.5 miles.
  - Among individual vehicles, the median distance varies substantially

- 57% of SC engagements have 1 or more <u>steering overrides</u> and 47% have 1 or more <u>driver awareness</u> reminders.

- When a driver awareness reminder is given, the <u>driver resolves the issue</u> before further SC escalation (red cues) in 91% of the cases.

  - The rate of driver awareness reminders does not increase with trip length.

- Beyond the first red escalation stage, there is <u>another escalation which will lock out</u> further use of SC until the next ignition cycle, which occurred for 32% of the vehicles with SC usage.

Driver awareness cues

Bar Flashes GREEN

Bar Flashes RED
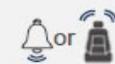
Camera-based Front Pedestrian Braking (FPB)

- Dataset size: 4965 vehicles, 14 months, 60M miles

- 98% of the vehicles used "Alert and Brake" driver setting (rather than "Off" or "Alert Only")

- For FPB feature:

	Alert	Auto braking
Rate per 100,000 miles	25.8	0.17
Mean speed at onset (MPH)	21.8	14.9
Percent of events off the road	18%	45%

- Speed reductions near FPB events will be examined in future analyses (e.g., many of these events could be short-lived)
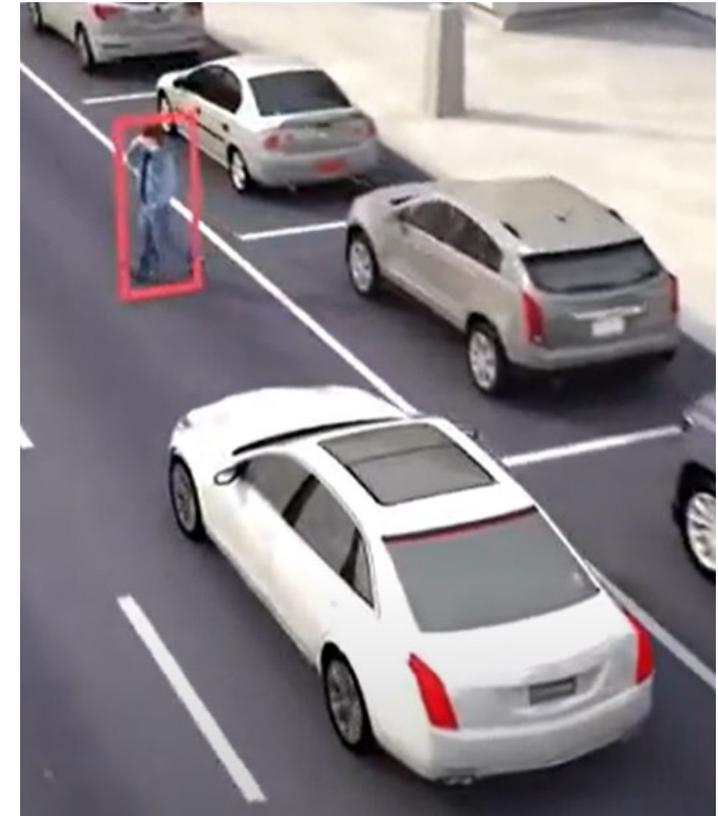
Operates between 5 to 50 mph, and has limited nighttime performance.

Comparing Rates:
Front Pedestrian Alert/Braking vs. Features from Previous Telematic Studies

ADAS Rates per 100,000 Miles
(logarithmic scale)

For reference, rates of police-reported crashes are 0.2 per 100,000 miles.
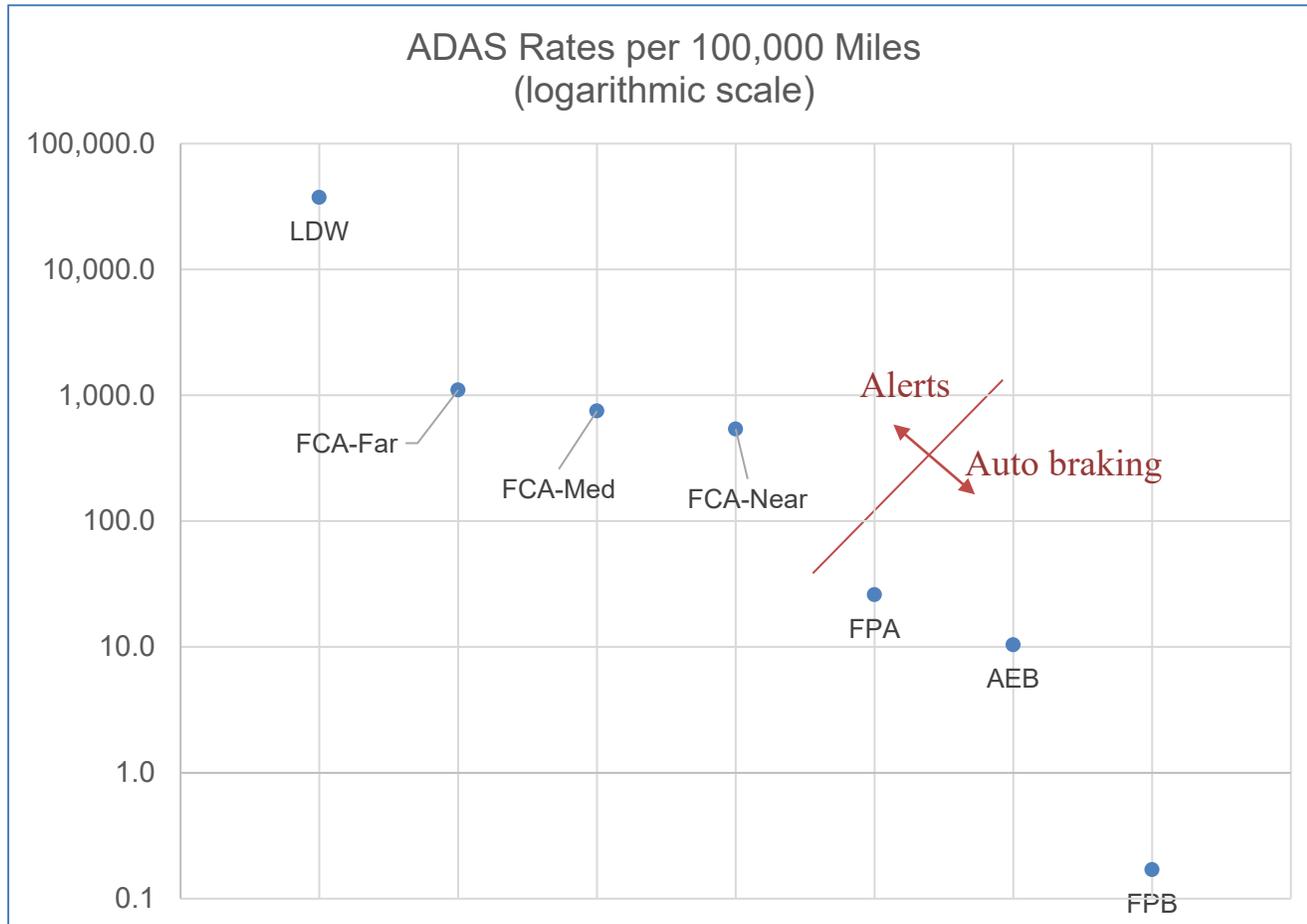
Phase III: Current study	
1457 vehicles sample	
Front Pedestrian Braking:	Per 100K Mi
Alert	26
Auto braking	0.17

Phase II: DOT HS 912615 (2018)	
2100 vehicles	
Auto Emergency Braking	10.4

Phase I: DOT HS 812247 (2016)	
1100 vehicles	
Forward Crash Alert	
Near setting:	1100
Medium setting:	750
Far setting:	540
Lane Departure Warning:	37,400

Summary of Ongoing Work

- Large-scale telematics-based data collection with thousands of vehicles under a wide range of real-world driving conditions offers efficient/timely study of ADAS feature usage/performance, driver interactions with features, and rare safety-related events

- L2 Super Cruise (SC) Study 1:
  - No AACN events over 1.7 M miles of SC-engaged driving, or during any motorway driving for SC or comparison fusion-based ACC fleets
  - SC was engaged for 18% of driving on compatible roads; median SC engagement was 2.7 miles
  - SC (similar to ACC) used more in free-flow, non-urban, night, non-rain, and non-curved road conditions
  - 57% of SC engagements include 1 or more driver awareness reminders, with 91% of these reminders resolved without further escalating alerts
  - 32% of vehicles have experienced lock out of Super Cruise for the remainder of the ignition cycle due to failing to respond to first red escalation alert
  - Modelling results under matched driving conditions suggest:
    - SC engaged median and top SC speeds under free-flow conditions did not exceed those of ACC/manual driving (slightly higher SC speeds under non-free flow could be due to selective use)
    - ACC/manual driving vehicles were 1.7 x's more likely to exceed 2.6 m/s^2 decel than when SC engaged

- Phase III project:
  - Addresses Level 2 Super Cruise and camera-based FPB – Study 1 report being completed.
  - Study 2 with newer Super Cruise on MY 2021 vehicles is underway.

Thank you!

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