



Assessment in Specific SAE Level 2-equipped Vehicle Crash-imminent Scenarios

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Project Objectives

1. Identify crash-imminent scenarios for L2-equipped vehicles from a variety of data sources

- SGO public data analysis to understand common L2 crash scenarios
- Supporting data analysis to understand variables and factors associated with L2 crash scenarios (e.g., Naturalistic driving study (NDS) data, Fatality Analysis Reporting System [FARS], Crash Report Sampling System [CRSS])

2. Evaluate L2-equipped vehicles with different vehicle configurations to understand potential effects on crash imminent scenario (CIS) outcomes

- Evaluate vehicles with different vehicle powertrains, drivetrains, and body styles
- Determine the effects of vehicle, environment, and driver factors on vehicle dynamic response for each crash-imminent scenario.

Data Description and Filtering Techniques

Data Set	Data Range	Total Cases	Filtering Methods
SGO	7/2021-8/2023	1,043	All crash cases in data set, L2 capable vehicles
SGO with loss of control	7/2021-8/2023	43	Only crash cases with loss of control indicated in the unredacted narratives, manually reduced, L2 capable vehicles
FARS	2016-2021	16,642	Vehicles in fatal crashes from calendar years 2016-2021, light vehicles with indications of loss of control in the Crash Type, Critical Pre-crash Event, Pre-impact stability, and Driver Related Factors coded variables (16 EV specific cases were identified)
CRSS	2016-2021	2,745,562 (n = 19,641)	Vehicles in non-fatal crashes from calendar years 2016-2021, light vehicles with indications of loss of control in the Crash Type, Critical Pre-crash Event, and Pre-impact stability (25 EV specific cases were identified)
SHRP 2 NDS	2010-2013	232	Crash and near crash events that indicate loss of control from the Precipitating Event and Narrative coded variables
VTTI L2 NDS	2019-2023	157	All crash and near crash events in data set, L2 capable vehicles (14 EV specific cases were identified)

Crash Datasets and Crash Type Prevalence

Data Set	Lane/Road Departures	Intersection Related	Rear-end Striking Excludes rear-end struck
SGO	57 (5.5%)	121 (11.6%)	190 (18.2%)
SGO with loss of control	6 (14.0%)	1 (2.3%)	4 (9.3%)
FARS	9,431 (56.7%)	1,529 (9.2%)	414 (2.5%)
CRSS	1,780,978 (64.9%)	559,888 (20.4%)	305,104 (11.1%)
SHRP 2 NDS	170 (73.3%)	75 (32.3%)	9 (3.9%)
VTI L2 NDS	10 (6.4%)	56 (36.9%)	64 (40.8%)

Results are representative of analysis of each individual dataset and are not directly comparable to one another

Selected Crash Test Types and Test Scenario Factors

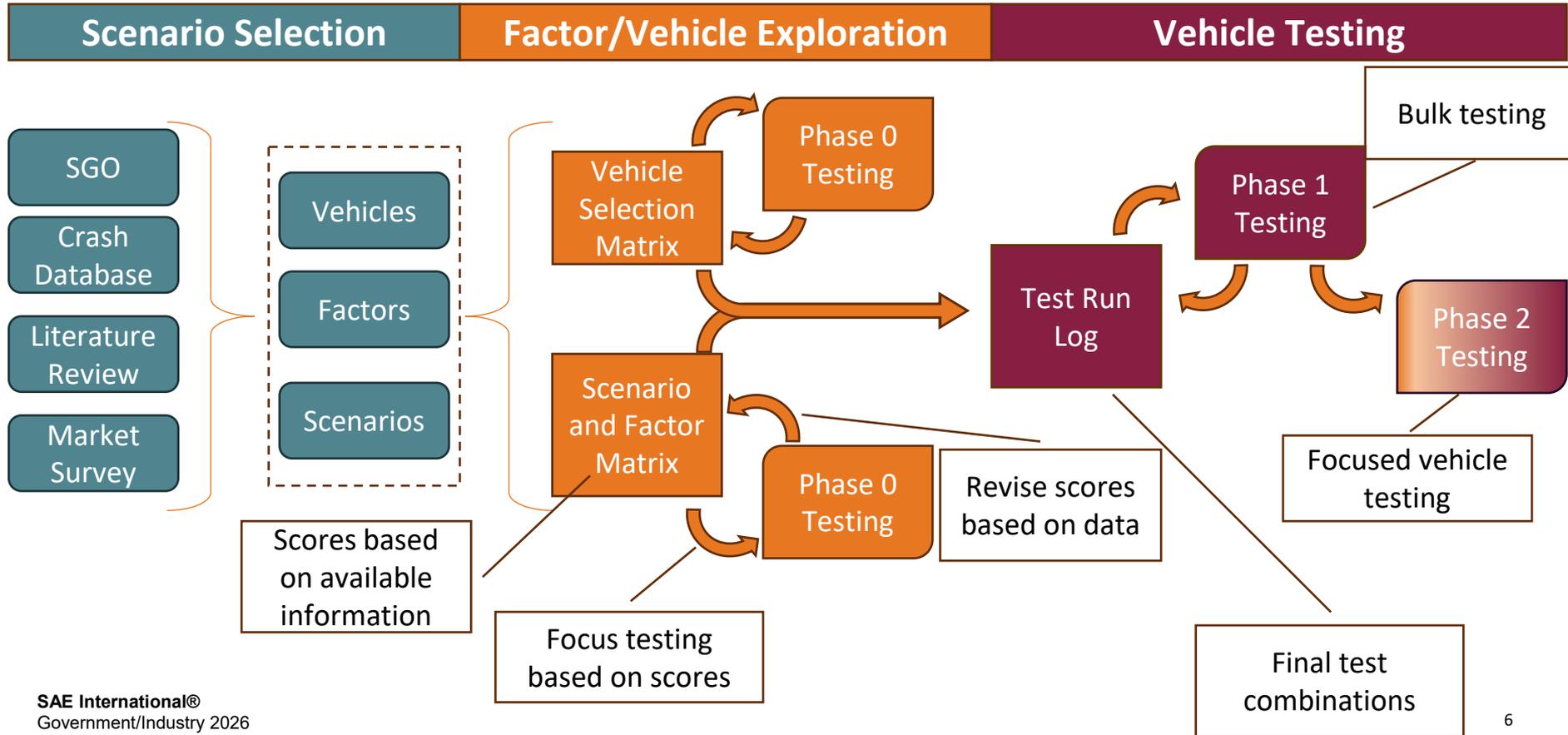
Three crash types selected for investigation

1. Lane / Road Departures
2. Intersection Related
3. Rear End Striking

Test scenario factors considered from crash data analysis

Vehicle Factors	Environmental Factors	Crash Factors
<ul style="list-style-type: none">• Powertrain: EV and ICE• Braking capabilities: regenerative, non-regenerative braking• L2 System capabilities• Active Safety Features: ESC, traction control, AEB• Tire wear	<ul style="list-style-type: none">• Roadway surface conditions: dry, wet• Roadway type: two-lane undivided roads, divided highways, intersections• Roadway alignment: curved, straight• Ambient Lighting conditions: daytime, nighttime, lighted, non-lighted	<ul style="list-style-type: none">• Subject vehicle speed• Crash Partner variations: road objects, other light vehicles, non-motorists• Crash Partner movements: cut-ins, lane changes, reveals, turn into/across path• Driver behavior: steering, braking inputs, distraction

Vehicle Test Summary



Test Vehicles



Tesla Model 3:

- BEV
- Sedan
- RWD
- L2: Autopilot, Autosteer+Traffic Aware Cruise Control

Ford Mach-E:

- BEV
- SUV
- RWD
- L2: CoPilot360

Jeep Grand Cherokee:

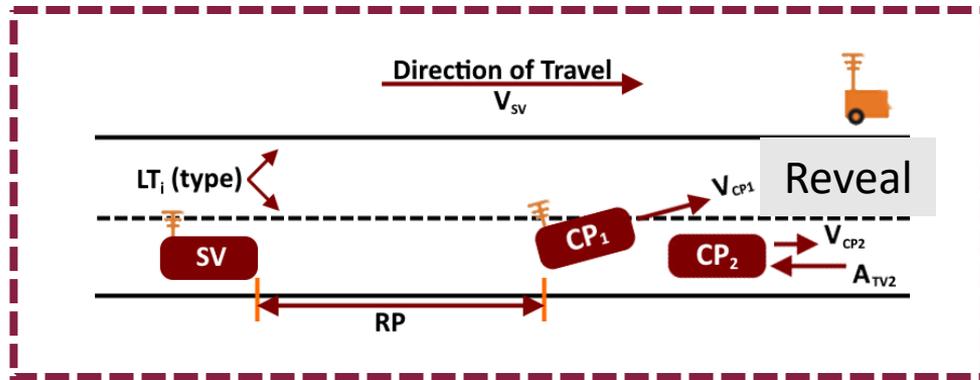
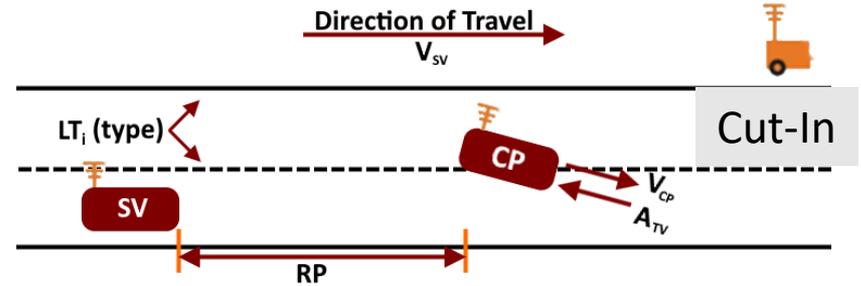
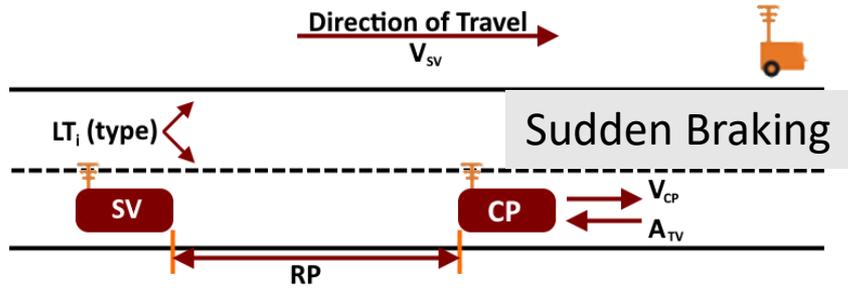
- PHEV
- SUV
- RWD/AWD
- L2: Active Driving Assist

Subaru Outback:

- ICE
- SUV
- AWD
- L2: EyeSight

Model 3 and Mach-E were selected for Phase 2 testing

Example Test Procedures – Rear-end Striking



Vehicles

- SV: Subject Vehicle
- CP: Crash Partner(s)

Factors

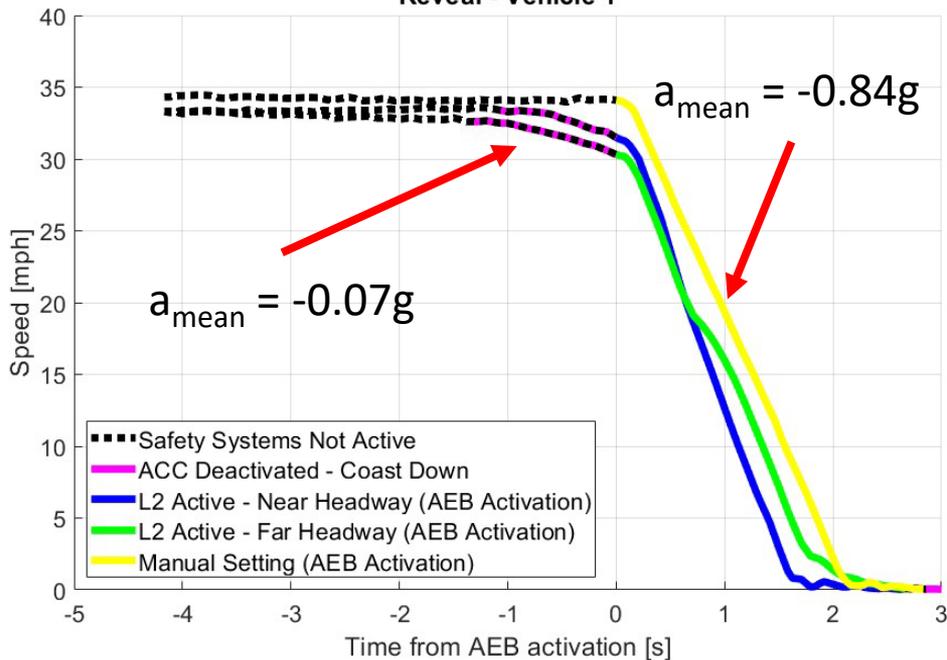
- V_{sv} : Velocity of SV
- V_{cp} : Velocity of CP
- A_{tv} : Acceleration of CP
- RP: Relative position between SV and CP

Reveal Results – L2/AEB Strategies

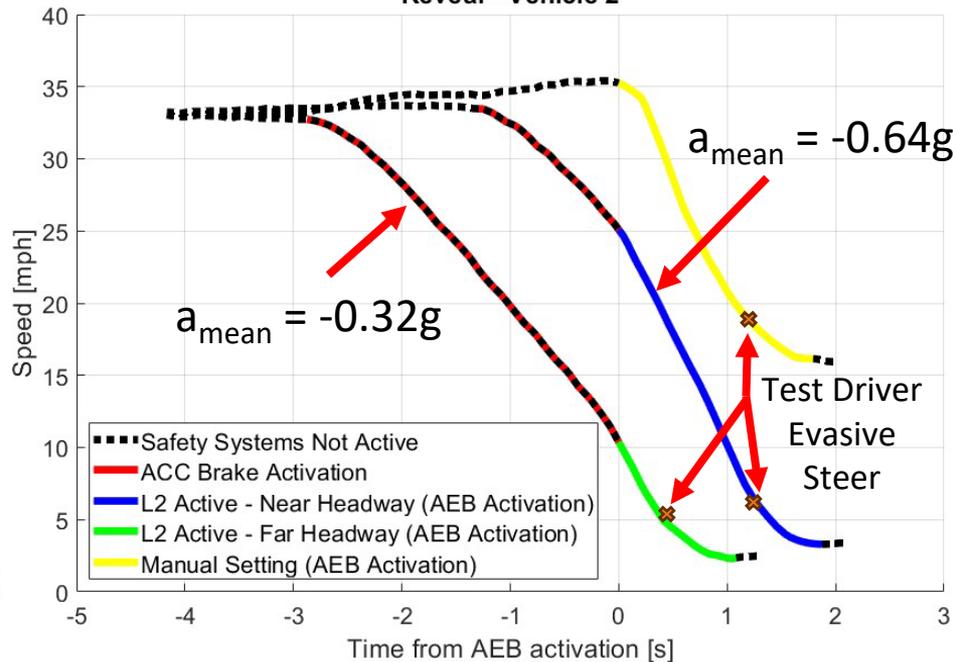
Vehicle 1: L2 Slowdown → Display FCW & Engage AEB

Vehicle 2: Use L2 to reduce speed → Engage AEB

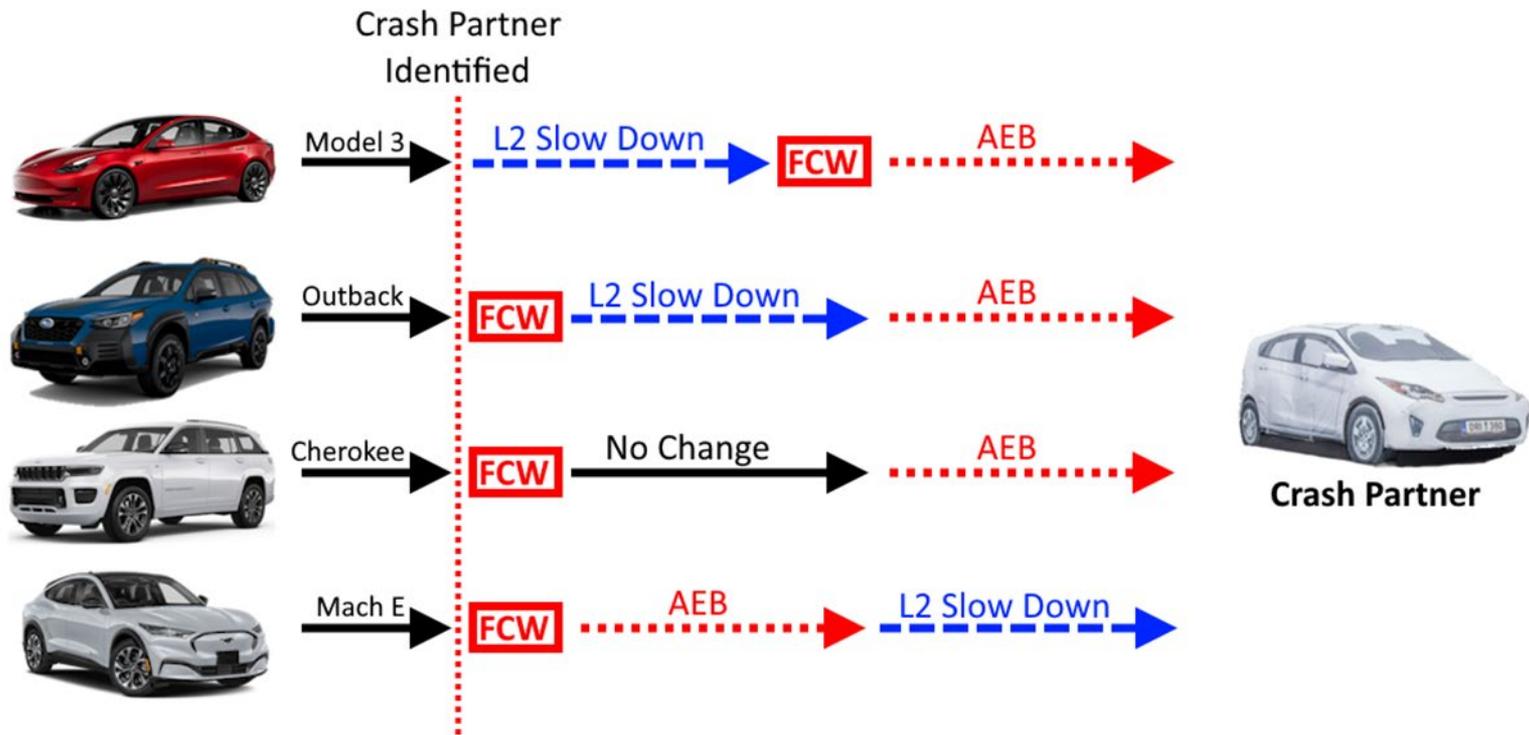
Reveal - Vehicle 1



Reveal - Vehicle 2



Reveal Results – L2/AEB Strategies



Key Takeaway: *L2, FCW, and AEB activation strategies vary by manufacturer*

Reveal Results – TTC Sensitivity

Lead Vehicle Speed	Lead Lateral Speed	Lead-Target Distance @ Reveal	TTC @ End of Reveal [s]	TTC @ FCW Activation [s]	TTC @ AEB Activation [s]
25 mph	1.86 m/s	Far (7.4 m)	2.793	-	(ACC)
25 mph	2.11 m/s	Far (8.5 m)	2.090	1.570	(ACC)
35 mph	1.35 m/s	Short (16.9 m)	2.069	1.633	1.307
35 mph	1.29 m/s	Short (16.5 m)	1.920	1.716	1.282
35 mph	1.69 m/s	Med (12.1 m)	1.700	1.578	1.137
35 mph	1.89 m/s	Far (8.8 m)	1.698	1.395	0.906
45 mph	1.29 m/s	Short (19.2 m)	1.707	1.368	0.688
45 mph	1.50 m/s	Short (13.3 m)	1.525	1.405	-
<i>Example Videos on Following Slides</i>					
45 mph	1.54 m/s	Short (23.3 m)	2.160	1.630	0.912
45 mph	1.67 m/s	Short (20.0 m)	2.051	1.642	0.958

Reveal Results – TTC sensitivity

Vehicle 1
Crash Partner Reveal
Lead Vehicle Speed - 45 mph (20.1 m/s)
Lateral Speed - 4.25 mph (1.9 m/s)



TTC End of Reveal – 1.74 sec
AEB activation

TTC End of Reveal – 1.48 sec
AEB did not activate

Key Takeaway: *L2 and AEB vehicle response are dependent on TTC when SV identifies CP, TTC ~1.7 seconds AEB activation threshold for all vehicles tested*

Summary and Next Steps

Summary

- Identified CIS from crash datasets and determined internal and external factor parameter values to support testing
- Developed and executed phased test architecture with three phases of testing to exercise the vehicle system with L2 engaged during CIS
- Evaluated vehicle system response with L2 engaged to understand the vehicle system performance during CIS and test factor sensitivity

Next Step

- High speed testing across the identified CIS to validate results at higher speeds

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Contact Info

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