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The Intersection of Engineering and Policy.

Results from a Large-Scale Telematic Field Study of a Level 2 System

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Field Study 2 of GM Super Cruise ("hands-off") – NHTSA Research supported

Objectives & Method

- Use OnStar telematics to capture selected data from large fleets of customer-owned vehicles in daily operation.
- Characterize the SAE level 2 Super Cruise in terms of real-world usage and safety-related metrics.

Study 2
2021 Cadillac Escalade

Study 1*

- 2,636 MY18-19 Super Cruise vehicles,
- 4,965 vehicles with camera ACC and PAEB,
- 1,175 fusion ACC baseline vehicles.

Today

Study 2

- 5,829 MY21 Super Cruise vehicles.
- Adds divided roadways with at-grade junctions and Lane Change On Demand.

Study 3 (scheduled)

- 10,000 MY25 Super Cruise (SC) vehicles.
- Expanded to undivided roadways, adds automatic lane change.

*Reported in 2022 SAE Gov/Industry

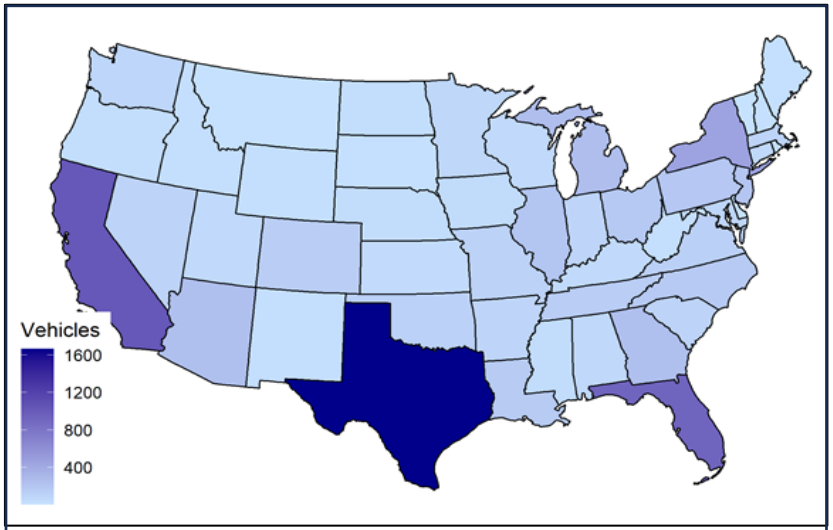
MY 2021 Super Cruise Overview

- SAE Level 2 partial driving automation technology (SAE J3016)
- Allows **hands-free** driving on compatible GPS-defined roads
- A **driver monitoring system** uses a face camera and a **series of escalating alerts** to prompt the driver to pay close attention to the road ahead and take steering control when takeover requests are issued.
- **A steering wheel light-bar** is used to communicate system status, along with other alerts and displays.
- Various sources of information detect vehicle position and environment:
  - Precision LiDAR map data Real-time cameras, GPS, and other sensors

- Dedicated brand-focused customer websites (e.g., *https://www.cadillac.com/technology/super-cruise*)

Study 2 Data Collection Scope

- 10 months of data collection
- 72% of the 5829 SC-equipped vehicles engaged SC at least once
- 422,000 separate SC engagements
- 2.8M miles with SC engaged
- No Advanced Automatic Collision Notification (AACN) events with SC engaged

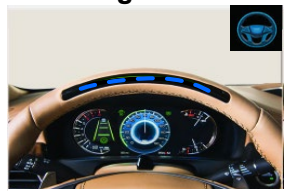


Vehicles from all states except Alaska & Hawaii

SC Engagements: Durations and Events

- SC engagement distances varied across individual vehicles and within the individual vehicles. Overall, the 15th and 85th percentiles for SC engagement event distances were 0.6 miles and 12.4 miles, with 3,888 events longer than 50 miles on limited access roadways (motorways).
- Driver awareness reminders occurred in 49% of engagement periods.
  - The driver resolved the issue before further SC escalation (to takeover request) in 90% of the cases.
- Super Cruise takeover requests (TORs) occurred for many reasons (248,883 TORs).
  - The next escalation stage occurred in 2.1% of TOR events and the vehicle may have slowed. (Drivers cannot use Super Cruise for the remainder of this key cycle after reaching this escalation stage.)
  - In 19 cases (< 0.01% of TORs), the vehicle came to a stop in its lane. Of these, the TOR occurred below 25 mph for 79% and always below 45 mph.

Steering over-ride



Driver awareness cues

Driving Environment Influences SC Usage Rate

- Use of Super Cruise in different driving conditions was mostly consistent with a trend in which drivers have more SC engagement events when driving conditions are less challenging.
- Study 1 reported similar directional changes for ACC-only vs. manual driving

Probability of SC engagement …	**Odds Ratios (OR) (More likely if OR > 1)** Super Cruise vs. Manual or ACC-only
In free-flow (100% vs. 50% free-flow)	2.10
In non-urban situations (vs. fully urban)	2.02
At night (vs. daytime)	1.67
In non-rain conditions (vs. medium rain)	1.67

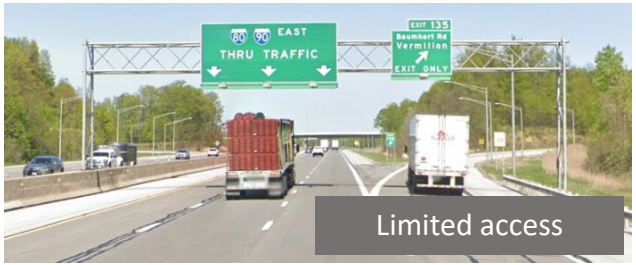
e.g., 2.10 times more likely to engage Super Cruise in this condition.

**Multivariate analysis considering free-flow, urban/not, rain, daylight, time of day, weekday.*

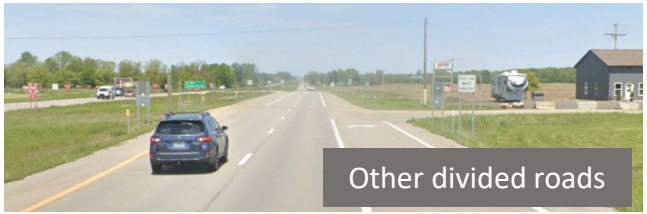
Super Cruise usage on two divided-road types

- Super Cruise in Study 2 operated on GPS-defined compatible divided roads
- Comparable usage statistics were found with the two road types:
  - Limited access roads (motorways)
  - Other divided roads (trunk roads)

SC-compatible road type	Engagement events	Engaged miles	85th %-ile miles per engagement
Limited access (motorways)	388,888	2,655,061	12.7 mi
Other divided roads (trunk roads)	33,571	169,772	9.7 mi
All roads	422,459	2,824,83	12.4 mi

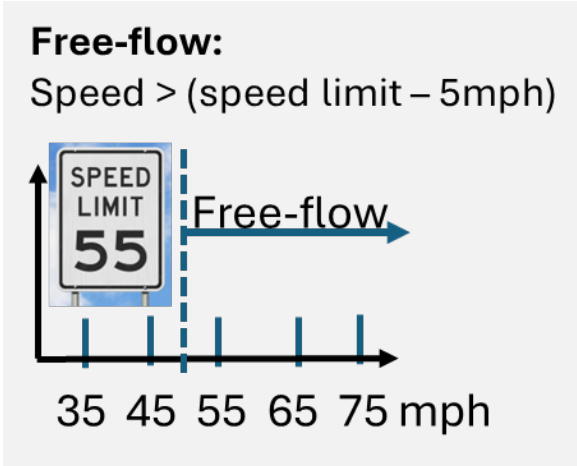


Limited access


Other divided roads

Super Cruise Usage and Lane Change Frequency

- Super Cruise use substantially decreased the rate of lane changes per mile.
  - The lane change rate was 54-75% lower during Super Cruise engagement.
  - The reduction was higher in non-free-flow conditions due to a higher rate for lane changes for manual driving in those conditions (up to a 74% increase over fully free-flow conditions)
  - The frequency of lane changes in Super Cruise is less variable across levels of free-flow than in manual/ACC driving.
  - Drivers used Lane Change on Demand (LCOD) more than steering override.



Speeds When Using Super Cruise

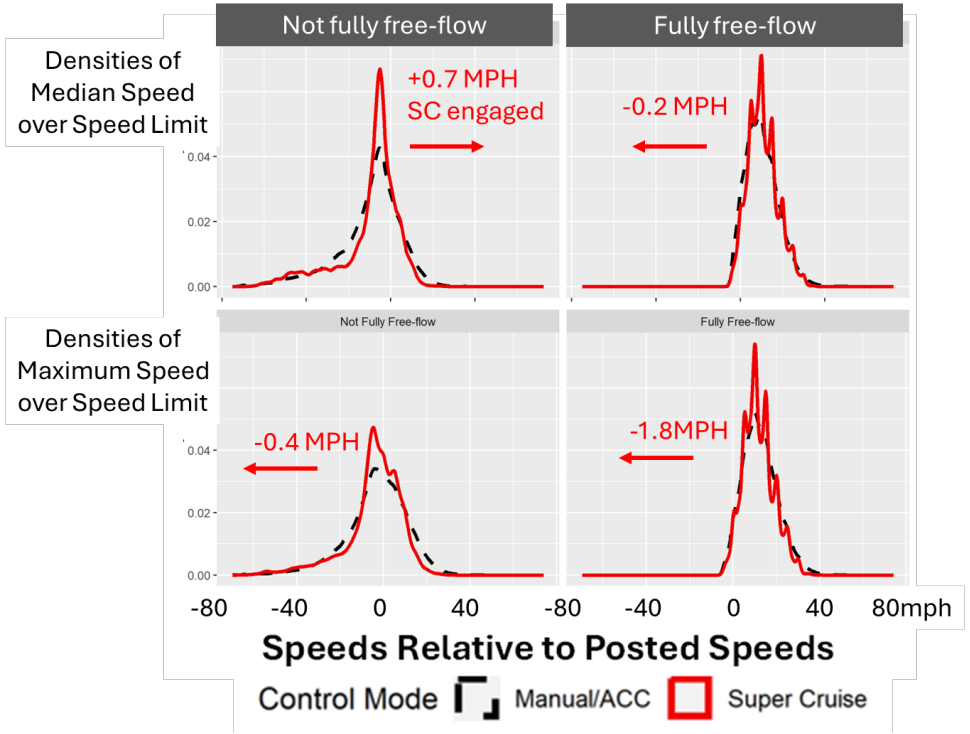
Free-flow conditions are when the minimum speed on the segment never falls 5 MPH below speed limit

In non-free-flow conditions:

- SC median speeds were 0.7 MPH higher than manual/ACC, and max speeds were lower (-0.4 MPH) than manual/ACC on average.
- Given other findings, this may be due to selective use of SC in less-hindered traffic.

In free-flow conditions:

- SC median speeds* were nearly identical (-0.2 MPH) to manual/ACC driving, and max speeds were lower (-1.8 MPH).



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

Hard Braking Events Decreased When Using Super Cruise (in free-flow situations; the dominant SC use case)

Among the analyses using deceleration as a measure of interest:

- Studied braking events that exceeded 2.6 m/s^2 deceleration using 105,748 “matched” driving passes*.
- There was a significant interaction with the presence of free-flow traffic.
- At the median level of free-flow (92%), the braking events were 37% less frequent. (At 50% free-flow, events were 22% less frequent).

** Matched on vehicle, road segments, time of day, weekday conditions.*

Summary

- 5,829 MY21 vehicles using telematics-based data collection across the US.
- Super Cruise Study 2 findings:
    - No AACN events over 2.8 M miles of SC-engaged driving.
    - SC used more in free-flow, non-urban, night, and non-rain road conditions.
    - 49% of SC engagements included 1 or more driver awareness reminders, with 90% of these reminders resolved without further escalating alerts.
    - Lane change rates were 54-75% lower during SC engagements, with largest effects in low free-flow conditions where manual driving had more lane changing. LCOD was the most common method of changing lanes when engaged in Super Cruise.
    - SC engaged median and top SC speeds under free-flow conditions did not notably exceed those of manual/ACC driving.
    - SC engaged vehicles were less likely to exceed 2.6 m/s^2 decel than when in manual/ACC driving.

Contact Info

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