# Analytic Report - Tesla Advanced Driver-Assistance System

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October 26, 2023

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## LETTER OF TRANSMITTAL

The purpose of this report is to analyze the issues with the advanced driver-assistance system (ADAS) features that are currently available in newer Tesla models. Tesla is under investigation by the National Highway Traffic Safety Administration (NHTSA), the U.S. Department of Justice (DOJ), and has several lawsuits pending regarding their Autopilot and Full Self-Driving (FSD) ADAS features. This report will outline the current issues that have been reported by consumers, as well as the investigations and lawsuits that have been reported in the media.

The research conducted for this report includes online searches for articles with the following topics to name a few.

1. Tesla user manual/instructions
2. Reports of Tesla issues and collisions
3. History of ADAS
4. NHTSA documentation on ADAS features and regulations.

If there are any questions about the content or the reader would like to discuss the included information, I welcome the request for a meeting to discuss. Thank you for your time and consideration.

## EXECUTIVE SUMMARY

ADAS has been included in most automobiles on the market in the twenty-first century. ADAS technology automates repetitive driver actions allowing the driver to avoid costly and dangerous collisions. Tesla ADAS features, Autopilot and FSD, have been under scrutiny and investigation in recent years due to several accidents and legal battles. This report will analyze various findings from published articles and provide recommendations to be considered to mitigate the issues summarized. The main issues are the cause of Tesla collisions while using ADAS technology causing injury or death and reports of legal cases regarding misleading marketing of the features.

Based on the findings, it appears that Tesla Autopilot and FSD ADAS features is at least partially at fault for the collisions which caused injury and death. It also appears, despite not breaking any actual laws, that the terms “Autopilot” and “Full Self-Driving” used by Tesla are misleading to consumers. Because of this, Tesla owners are overutilizing and improperly engaging the features. In my opinion, some of the issues can be rectified if Tesla accepts some of the blame and voluntarily makes some needed changes to their ADAS feature names, as well as properly instruct owners at the time of purchase, and ongoing with each software update, how the features have been designed to be used. In addition to owner education, Tesla must make some needed updates to their ADAS technology to assure drivers that Tesla safety is their priority over profit.

## PROBLEM

The analysis was designed to understand and potentially answer the following questions.

1. What is an advanced driver-assistance system?
2. What issues have been reported with Tesla's ADAS Autopilot and Full Self-Driving systems?
3. Were the reported collisions involving Tesla models due to malfunction in the ADAS features or were they due to driver inattention and overreliance in ADAS?
4. Is Tesla using deceptive marketing techniques regarding the ADAS features?
5. What should be done to mitigate the issues with Tesla model ADAS features?

## BACKGROUND

Since the 1970s, when the first ADAS feature was developed with the electronic anti-lock braking system, ADAS has been at the forefront of automotive technology enhancements. Since that time, there have been many innovations from cruise control and lane departure alerts to autosteering and Smart Summon technology (ADAS: Everything You Need to Know). The United States Department of Transportation's NHTSA regulates the safety of vehicle automation and has established six levels of automation (see figure 1). According to NHTSA, their "mission is to save lives, prevent injuries, and reduce the economic costs of roadway crashes through education, research, safety standards, and enforcement activity." NHTSA reported that "9 out of 10 serious roadway crashes occur due to human behavior, automated vehicle technologies possess the potential to save thousands of lives,

as well as reduce congestion, enhance mobility, and improve productivity (Automated Driving Systems 2.0: A Vision for Safety).

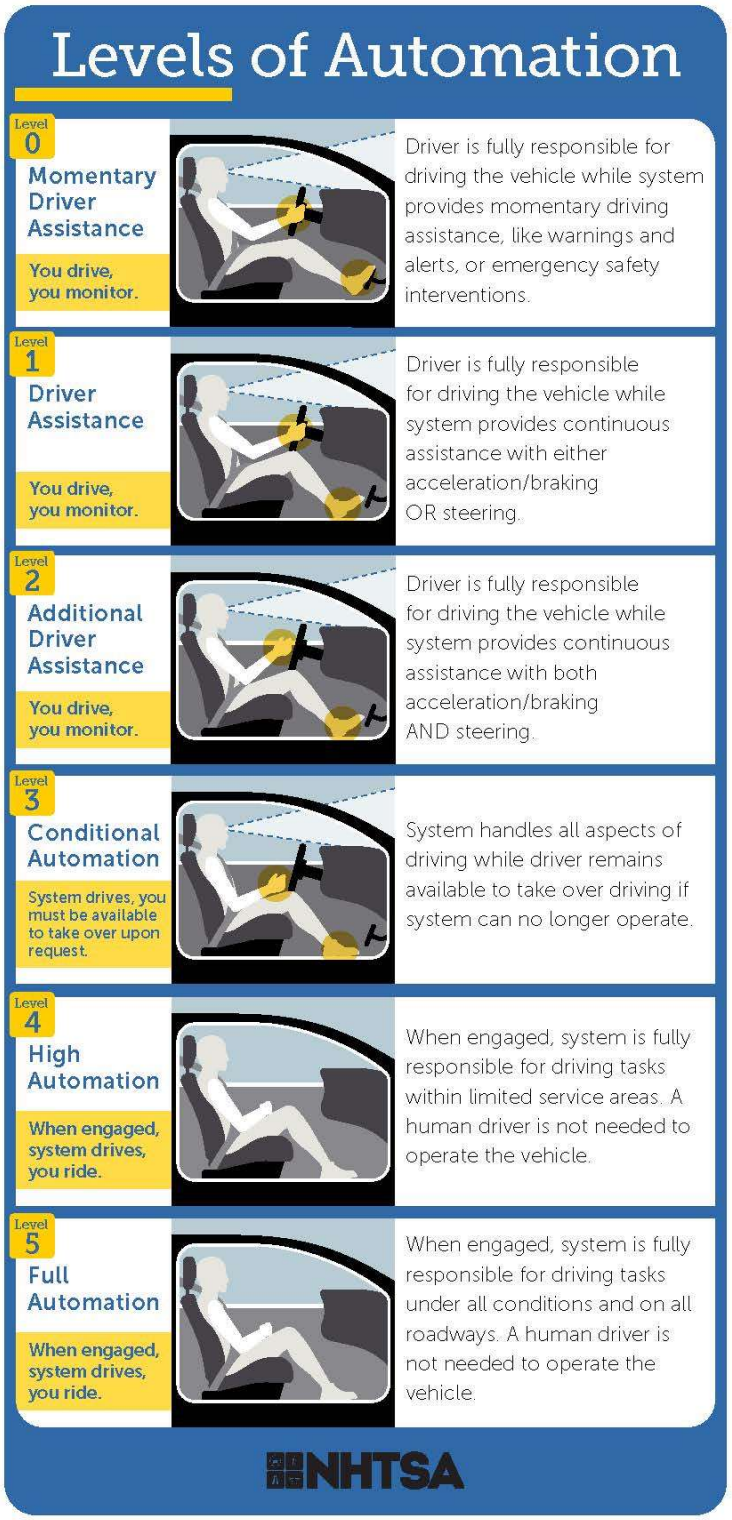


Figure 1: Levels of Automation from Levels of Automation

Many automobile manufacturers produce vehicles with varying ADAS features. Tesla's Autopilot and Full Self-Driving fall into level two automation which requires the driver to be fully responsible for the operation of the vehicle. This type of automation requires the driver to be alert and ready to take immediate action in the event the automation does not perform accordingly. Tesla's owner's manual has such warnings throughout the sections about Autopilot and FSD capabilities. Several of the warnings begin with "Autopilot/ FSD is a hands-on feature" while other paragraphs warn "features do not make the vehicle autonomous" (About Autopilot, Autopilot and Full Self-Driving Capability).

Despite these warnings on the Tesla owner's manual, there have been various reports indicating Tesla has been the focus of intense scrutiny, various lawsuits, and NHTSA and DOJ investigations due to ADAS marketing concerns and issues with its Autopilot and FSD systems. These problems with Tesla ADAS are analyzed in this report. From the analysis, findings and recommendations are presented.

It is important to first understand what ADAS is, the ADAS levels, and types of ADAS features that are available on the market. One source describes ADAS as "technological features that are designed to increase the safety of driving a vehicle." The same source makes a very important point stating "when properly designed, these systems … use a human-machine interface to improve the driver's ability to react to dangers on the road" (ADAS: Everything You Need to Know). In terms of how ADAS is designed, the source describes ADAS as using data gathered from the primary vehicle to enable the features.

Some types of ADAS sensors that are used to gather data to create a 360-degree view of the vehicles environment are the following (Smith). See figure 2 for the type of ADAS features that are associated with each sensor type.

- Light detection and ranging (LiDAR) – Lasor sensors that measure reflection time to detect objects and map their distance in real time. LiDAR are integrated with inertial measurement unit (IMU) and Global Positioning Systems (GPS).
- for computer vision that transforms output into 3D." It can "discern between static and moving objects for added layers of blind-spot or bad-lighting situations."
- Cameras – Uses images and output to build a 3D model of the vehicle surroundings which are fed to the computer system where they are processed where objects are identified.
- Radio Detection and Ranging (RADAR) – Sensors emit radio frequencies and measure the "returned reflections" to determine the size, distance, and speed of an object.
- Ultrasonic – High-frequency audio bursts that reflect other nearby objects. Reflections are measured to detect objects.

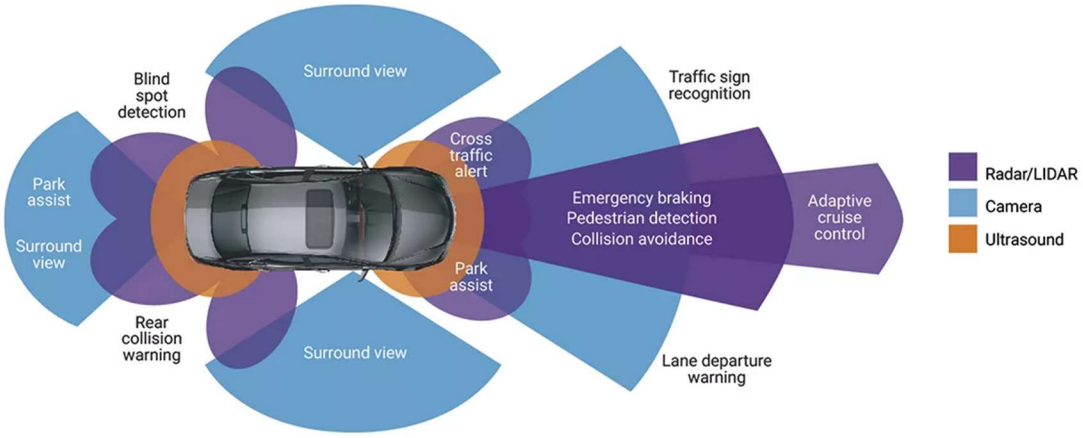


Figure 2: ADAS from What is ADAS?

The NHTSA has broken down the "Five Eras of Safety" to indicate automobile safety, convenience, and ADAS features by the era of introduction. As you can see in figures 3 and 4, many of the amazing innovations available on the market were first introduced in the twenty-first century. Automakers have continued to develop many ADAS innovations that have brought automation technology closer to level 5, a fully automated automobile no longer requiring a human driver (see figure 1). The ADAS features "collectively… could impact 3.59 million total crashes per year, or about 62% of all crashes" (Advanced driver Assistance Systems – Data Details). Figure 3 shows the impact of various ADAS features on the annual number of crashes.

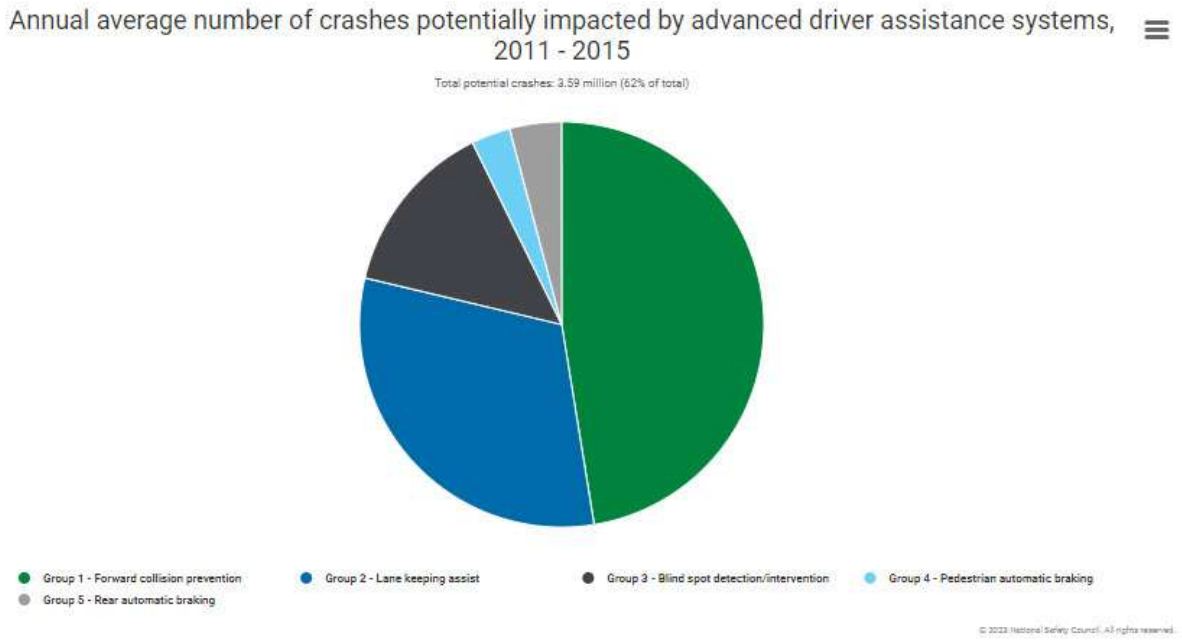


Figure 3: Annual average number of crashes potentially impacted by ADAS from Advanced driver Assistance Systems – Data Details

Tesla has faced much scrutiny and several lawsuits based upon issues with their latest technology advancements that are summarized in the Discussion of Findings section. Despite this, Tesla continues to promise a fully automated vehicle soon. Musk was quoted as saying "the vehicles to be built on Tesla's next-gen platform will operate 'almost entirely in autonomous mode' during an appearance at a conference (Lambert).

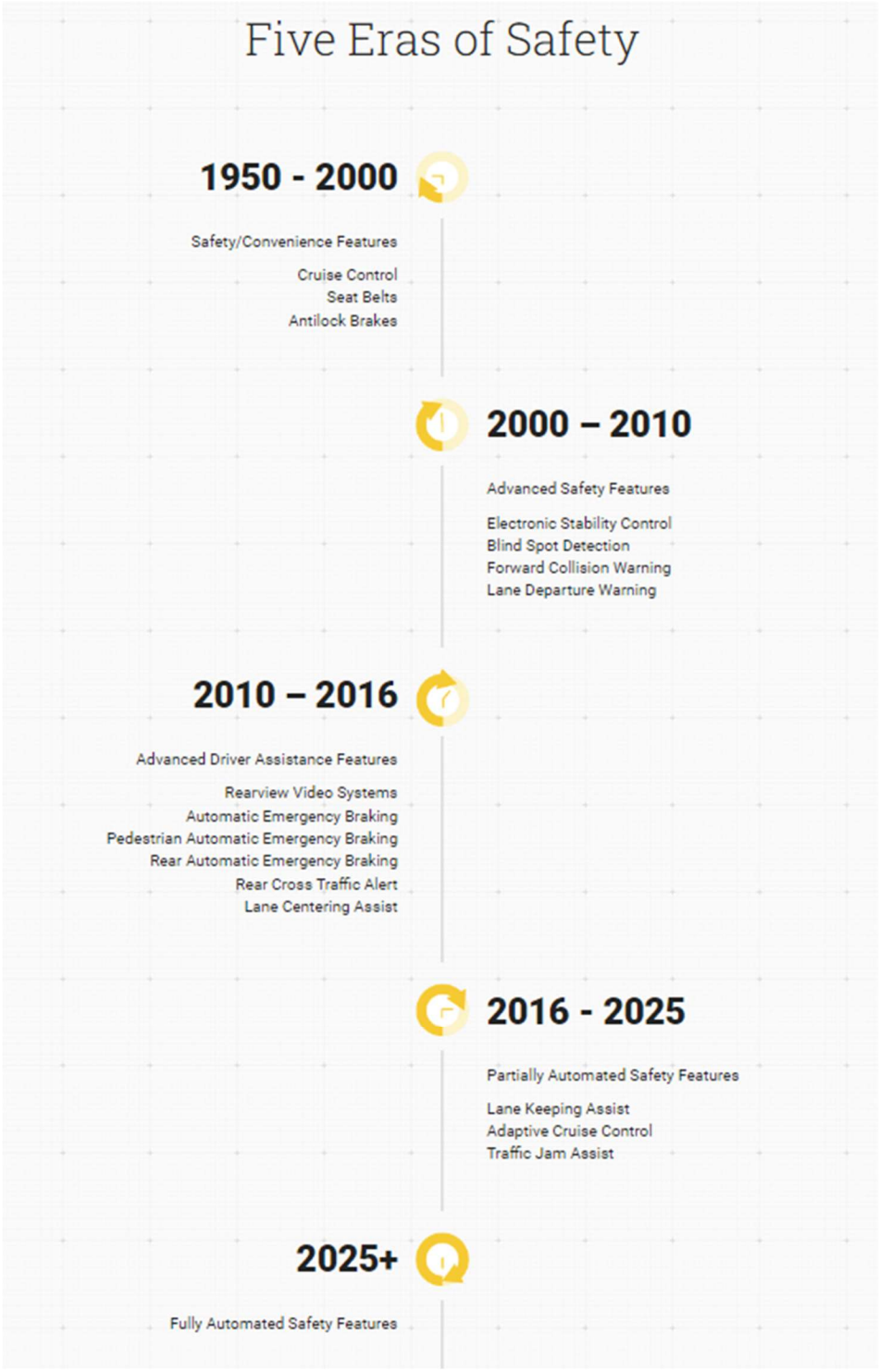


Figure 4: Five Eras of Safety from Automated Vehicles for Safety

## DISCUSSION OF FINDINGS

The research findings address several facts below that are pertinent to the scrutiny that Tesla has faced lately.

1. Several occurrences of Tesla automobile collisions that were due to either suspected ADAS malfunction and/or where driver inattention and ADAS overreliance was involved or a combination of both.
2. Reports that indicate some of the ongoing issues that occur with ADAS in Tesla models.
3. Legal issues and regulatory inquiries that were brought against Tesla.
4. Recent changes to the sensors used in Tesla ADAS features.

## TESLA COLLISIONS

- May 7, 2016 – A Tesla Model S, traveling on a divided highway, had Autopilot engaged and collided with a tractor trailer that was making a left turn at an intersection in front of the Tesla. The Tesla "passed under the trailer," killing the Tesla driver. Tesla explained the "high ride height of the trailer combined with its positioning across the road" was the cause of the collision. Tesla assured "the risk of injury will decrease as Autopilot gets better over time" (Nishimoto).
- March 1, 2019 – A Tesla Model 3 traveling on a highway had Autopilot engaged and collided with a tractor trailer that pulled in front of it from a side road. The Tesla's data log, cameras, and witness accounts showed the following:

- Cruise Control was set to 69 mph (the speed limit on highway US441 was 55 mph) and Autopilot is also set.
- About five seconds into the drive, “no driver-applied wheel torque” was logged meaning the driver’s hands were not on the wheel.
- Tesla cameras captured images of the tractor trailer appearing in front of the Tesla. However, there was no warning of the obstacle in the Tesla’s path.
- Autopilot does not apply the brakes.
- The Tesla collided with the tractor trailer removing the hood of the automobile instantly killing the driver.
- The Tesla continues moving for another 40 seconds before coming to a stop.

Based on the reconstruction of the accident, the Tesla warning “Please keep your hands on the wheel. “Be prepared to take over at any time” would have appeared after 25 seconds without hands on the steering wheel. However, the collision with the truck occurred prior to that warning.

The National Transportation Safety Board (NTSB) investigation determined that a combination of the Tesla’s “driver inattention,” the “truck driver’s failure to yield to oncoming traffic,” the Tesla’s driver’s “overreliance on automation,” and “Tesla design that ‘permitted disengagement by the driver’ contributed to the collision.”

“Tesla noted … that Autopilot was not designed to reliably detect cross-traffic, or traffic moving perpendicular to a vehicle” (Thadani, et al.).

- March 17, 2021 – A Tesla Model 3 driving on a freeway with Autopilot engaged was involved in a collision with a stationary Michigan State Police vehicle. Neither the Tesla driver nor Autopilot applied the brakes (Kierstein).
- August 28, 2021 – A Tesla driving on a highway with Autopilot engaged was involved in a collision with a stationary Florida State Police vehicle. The trooper "narrowly missed being struck as he was outside of his patrol car" (Shepardson, "U.S. Identifies 12th Tesla Autopilot…").
- April 22, 2022 – A Tesla Model Y Full Self-Driving (Beta) Summon feature was engaged with the driver outside of the vehicle and the vehicle drove itself into the tail of a Cirrus Vison jet. After colliding with the stationary jet, the Tesla does not immediately stop, it continues and causes the plane to move 90 degrees (Gold).
- November 24, 2022 – A Tesla Model S driving through a tunnel with the Full Self-Driving (Beta) feature engaged. The Tesla activated the left turn signal and brakes while proceeding to make a lane change to the leftmost lane until it slowed and came to a complete stop under the bridge. Eight vehicles crashed into the Tesla from behind. There were nine people injured in the collision but there were no fatalities (Gold, Klippenstein).

**INCIDENT REPORTS**

- A Washington Post analysis of NHTSA data showed 736 collisions in the U.S. since 2019 that involved Tesla models with Autopilot engaged. (Blanco) The "number has surged over the past four years, the data shows" according to Siddiqui. "The most recent data includes at least 17 fatal incidents, 11 of them since May 2022" Patterns

found by the Post show that incidents involved motorcycles and emergency vehicles. According to the Post, the possible cause of increase in collisions may be the expanded release of Full Self-Driving Beta to 400,000 people which is when two-thirds of collision reports were reported. Out of the 807 total automation-related collisions, the overwhelming majority (91%) involved a Tesla while only twenty-three involved a Subaru, ranking second (see figure 5) (Blanco, Siddiqui).

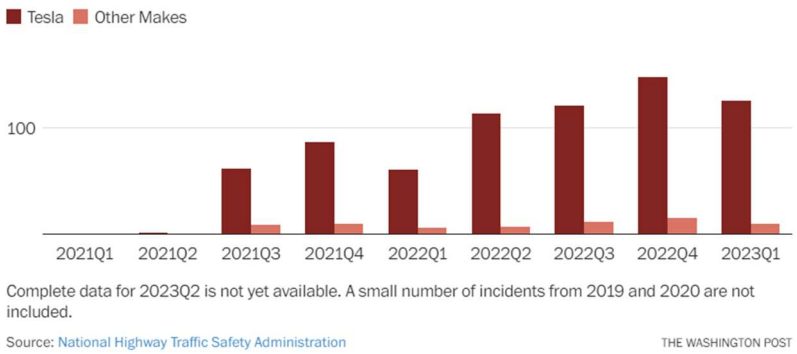


Figure 5: Crashes involving Tesla's driver assistance system have grown from Siddiqui, et al.

- A Tesla internal data leak to German media outlet Handelsblatt included "thousands of customer complaints" about Full Self-Driving features. The reports include "over 2,400 self-acceleration issues and 1,500 braking problems, including 139 reports of 'unintentional emergency braking' and 383 reports of 'phantom stops' from false collision warnings." The NHTSA began an investigation into FSD in January 2023. In February 2023 NHTSA "deemed the capability a crash risk" putting drivers in danger which led to the "recall of 362,758 cars equipped with FSD and pause FSD installations" (Roth, Tesla Recall Hits Nearly 363,000 Cars With "Full Self-Driving" Software).

## TESLA LEGAL ISSUES

### Deceptive Marketing Practices

- The California Department of Motor Vehicles (DMV) has filed two complaints with the California Office of Administrative Hearings against Tesla. The California DMV "has accused Tesla of engaging in deceptive practices around the marketing of its driver assistance systems, which are branded Autopilot and Full Self-Driving in the U.S." The DMV believes "these 'Autopilot' and 'Full Self-Driving Capability' labels and descriptions represent that vehicles equipped with the ADAS features will operate as an autonomous vehicle, but vehicles equipped with those ADAS features could not at the time of those advertisements, and cannot now, operate as autonomous vehicles" (Kolodny).
- A German regulatory agency, Wettbewerbszentrale, "alleged that Tesla's use of the words 'Autopilot included' in its vehicles was misleading marketing since the EVs still require a driver to operate. On appeal the Higher Regional Court of Munich ruled in favor of Tesla. However, Tesla was required to change some of the verbiage on its German website to clarify its "vehicle's future features" (Alvarez).

### Regulatory Agencies Investigations

- The National Highway Traffic Safety Administration launched an investigation (one of several) in 2021 regarding the Tesla Autopilot feature due to the number of crashes that had been reported with stationary emergency vehicles. (Peters)
- The U.S. DOJ) "has requested documents from Tesla related to its Autopilot and 'Full Self-Driving' features." An executive at the Center for Auto Safety believes that the DOJ may be investigating safety issues with the features or claims that Tesla has made that the cars can drive themselves. (Krisher, McFarland)
- The National Highway Traffic Safety Administration investigating a collision in May 2016 that killed the driver of a Tesla Model S with Autopilot engaged found that "system safeguards were lacking" according to a NTSB chairman. He also stated that "Tesla allowed the driver to use the [Autopilot] system outside of the environment for which it was designed, and the system gave far too much leeway to the driver to divert his attention" (Shepardson, "'System Safeguards' Lacking").

**Individual Lawsuits**

- Justine Hsu vs Tesla – Hsu claimed that twenty seconds after engaging Autopilot on her 2016 Tesla Model S the ADAS feature malfunctioned when it did not detect and subsequently caused the vehicle to hit the median and deploy the airbags causing injuries that required three surgeries. Tesla won the lawsuit when the jury believed that the Autopilot feature did not malfunction (Wood).

- Wrongful death of Jeremy Banner – The family of Jeremy Banner is suing Tesla after his Model 3 did not slow or stop when a tractor trailer pulled in front of it from a side road causing the roof of the vehicle to be "sheared off" (Thadani, et al.)

## RECENT CHANGES IN TESLA ADAS SENSORS

Tesla has recently changed their ADAS technology from radar sensors to camera sensors in a cost cutting measure he describes as his "first principle" which eliminates complexity. According to one source, Musk would "give into his "first principle" approach and "delete radar" from every Tesla model" (Tara) Two sources say that despite nineteen Tesla employees who reported that radar is needed, "Tesla remains the only car with Level 2 or Level 3 autonomy that uses only camera vision… every other auto manufacturer uses a combination of sensor technologies such as radar and ultrasonic along with cameras" (Mulach, Tara).

## CONCLUSION AND RECOMMENDATIONS

The collisions summarized in the findings section shows that on more than one occasion the ADAS of the Teslas involved in the collisions (1) did not identify objects in the vehicles path appropriately (e.g., tractor trailer, emergency vehicles, jet, road median), (2) failed to issue a safety warning in a timely manner when the driver's hands were not on the steering wheel, and (3) improperly engaged ADAS features.

Tesla does not appear to properly market or educate owners of the safe way to use the ADAS features, Autopilot and FSD. Tesla also does not appear to have sufficient safeguards in place to prevent driver misuse and overreliance of the ADAS features.

The data analyzed by the Washington Post shows that Tesla has the most occurrences of any automaker of ADAS related collisions.

Finally, the data and subsequent NHTSA investigation concluded thatTeslas ADAS features were putting drivers at risk of collisions, thereby leading to a recall of 363,000 vehicles.

The recommended actions to resolve or mitigate these problems, in my opinion, are as follows.

1. Stronger education of Tesla owners and potential consumers about how to safely operate the ADAS features in their vehicles.
2. Rebranding the Autopilot and Full Self-Driving features to terms that do not imply that the car is autonomous.

3. Sufficient testing of ADAS features in development prior to their over-the-air releases.
4. Restriction of ADAS features to the conditions for which they were intended. For example, when a feature is only intended for use on a particular type of highway, then use GPS to ensure that the feature is not enabled elsewhere.
5. More timely and more effective strategies to monitor driver inattention. For example, use sensors within the vehicle that identify that the driver's eyes are open and looking forward or identifying that the driver's hands are off the wheel sooner and engaging stronger methods such as an attention-grabbing noise in addition to the displayed warning to gain driver attention. If the driver becomes inattentive for over 5 seconds repeatedly, engage a slowing and lane change maneuver to slowly pull the driver to the shoulder of the road.
6. Return to RADAR or LiDAR sensors in addition to cameras as was recommended by several Tesla engineers.
7. Change in Tesla culture where the company is committed first and foremost to driver safety.

If some if not all these changes are put in place, I believe that Tesla vehicles will become safer. Tesla can then find themselves able to invest in furthering technological innovations in ADAS instead of spending time and money defending legal issues.

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