

Tesla Autopilot and Collisions with Stationary Emergency Vehicles

Joseph Rice

Car for the future, or doomed for failure?

According to Elon Musk, Tesla represents the future of driving. For one, their electric vehicles don't rely upon the highly polluting gas combustion engines of the past and increase the world's sustainable practices, with a new reliance upon electricity, rather than oil. Secondly, Musk argues that autonomous driving could have the potential to save millions of lives while also allowing passengers to do other things than stare out the windshield.¹

Numerous articles and experts paint an interesting picture of Tesla's autonomous driving software. Auto-manufacturing consultant, Sandy Munro, highly praised the development of Tesla's Full Self-Driving, saying it drove as aggressively as he does (in a good way). He believed Full Self-Driving would save more lives than anything else in the future, like Musk's earlier claim.²

On the other hand, several lawsuits have been filed against Tesla alleging false advertising. Two brothers from Santa Barbara, California, filed suit claiming Tesla sales staff confirmed their belief that they would be able to work while using the car on Autopilot and even told the brothers that they had driven tens of miles without touching the controls more than once or twice. Additionally, they claim they were told by Tesla staff that their car would soon become autonomous over the next few years.³

Tesla has been making strides toward autonomous driving. However, Tesla has never claimed that its Autopilot (as it is now) is a replacement for human driving. In all statements and on every page of the Tesla website, the company has marketed Autopilot as an advanced driver assistance system that includes two features: traffic-aware cruise control and autosteer. More simply, Autopilot can match the speed of surrounding traffic and stay within clearly marked lanes.

Additionally, Tesla owners can purchase what Tesla calls ‘full self-driving capability,’ which includes a greater suite of features. Among these are auto lane changes, auto park, summon, and traffic and stop sign control.⁴ As mentioned before, Tesla includes the caveat with each feature that they require the driver to remain fully active and aware during usage of Autopilot and that the vehicle is, in fact, not autonomous.

While Musk claims autonomous driving could potentially save millions of lives (without providing a timeframe), an Intel study estimates that a little over half a million lives could potentially be saved between 2035 and 2045.⁵ In other ways, Teslas are perhaps making the roads more dangerous. From the introduction of Autopilot to April 19, 2021, there were at least 11 deaths in 9 crashes involving Autopilot.⁶ As to these deaths, a major question concerns who is responsible. In one case, the driver involved in an accident resulting in the death of two people was charged with vehicular manslaughter, allegedly the first person in the United States to be charged with a felony using a partially automated driving system.⁷

Critical to understanding incidents involving Teslas on Autopilot is who is to be held responsible. Is Tesla falsely marketing its product to consumers? Is Autopilot a flawed system that must be recalled? Are inattentive drivers the main culprits? Regardless, there are many different facets to crashes involving Teslas, and there doesn’t appear to be one perpetrator to point fingers at.

Governance and Technology

There are multiple layers to how lawmakers and experts believe Autopilot, and Tesla in general should be regulated. Two Democratic Senators, Richard Blumenthal, and Edward J. Markey wrote a letter to the chair of the Federal Trade Commission to open an investigation into Tesla’s an advertising and marketing of its autonomous driving systems. In their letter, they argue

that Tesla has incorrectly portrayed its cars' features through YouTube videos of the cars driving on their own, tweets from Musk 'boasting' of Tesla's capabilities, and various claims from Musk that Tesla will 'soon reach' full automation.⁸

In their letter, however, they acknowledge that Tesla does have disclaimers on its website and Musk has given precautions on social media. Despite these, they still claim that consumers have been misled by the company and that Tesla and Musk are responsible for Tesla drivers' overconfidence in Autopilot and Full Self-Driving.

Tesla crashes are frequently met with mixed reactions about the events which occurred and what needs to be done next. Another prominent accusation of Tesla as being misleading came from the head of the US National Transportation Safety Board following several fatal crashes. She argued that Full Self-Driving is not truly self-driving technology and that consumers are being misinformed by the company. Another one of her concerns was that Autopilot was being granted to drivers who received no training or education on all its abilities and how to use it.⁹

While most controversy regarding Tesla comes out of the United States, other countries have criticized Tesla's marketing strategy as well. A court in Munich, Germany ruled that Tesla misled consumers regarding Autopilot and that their product did not meet the standards of what Tesla claimed it did. Additionally, the court banned Tesla Germany from marketing Teslas as having 'full potential for autonomous driving' and 'autopilot inclusive.'¹⁰

Numerous actors around the world believe Tesla is incorrectly marketing its Autopilot and Full Self-Drive. As Tesla itself admits, its cars are not truly autonomous. Full Self-Drive is not truly driving itself without the necessity of an attentive human passenger. However, is Autopilot as misleading? Given that Full Self-Drive is a subscription service, not all Tesla drivers are paying for it. Do they believe that Autopilot is just as intensive as Full Self-Drive? Does the term

‘autopilot’ have certain meanings that Tesla has chosen to ignore and continue marketing for the sake of business? Should the US government take similar steps to the German court system and also ban the usage of the terms ‘autonomous’ or ‘self-drive’?

Governing Tesla’s marketing of its product has proven to be a gray area. Another gray area, and one which calls into question whether Tesla is cutting corners in its pursuit of autonomous driving, include the Autopilot technology itself. While a more in-depth of autonomous driving technology will be included in subsequent sections, Tesla’s usage of cameras has caused a stir in the autonomous driving world.

The early history of Tesla’s technology included a combination of both cameras and radar. To put it simply, radar is better at detection while cameras are better at identification, and a combination of both could prove successful. However, Musk told Tesla engineers that the cars shouldn’t have to have radar and could rely only on cameras. This broke with industry practice, as a vast majority of companies developing autonomous driving use radar. On their website, they lay out their transition to Tesla Vision, a system completely reliant on camera vision and neural net processing and free of all radar technology. The switch began in May 2021 for the Model 3 and Model Y and began in mid-February 2022 for the Model S and Model X.¹¹

Ditching the radar in favor of cameras was possibly both for aesthetics and cost reduction. Lidar devices, a special kind of radar device, are very large, bulky, and expensive. On the other hand, cameras are smaller and cheaper, allowing Teslas to be sleeker and more aesthetically pleasing.¹²

At the 2022 Consumer Electronics Show, lidar company Luminar tested their technology next to a Tesla Model Y utilizing cameras only. In the test, a small child-size dummy walked across the road, which would normally be unable to be seen by a human behind the wheel.

However, in the first test with just the Luminar-equipped Lexus, the car swerved out of the way. In the second test, with the Tesla next to it, the Lexus stopped, and the Tesla struck down the dummy.¹³

Lidar is not without its flaws, and cameras are not all bad. However, this test shows that perhaps Musk's vision for a camera-only autonomous driving system is not as smart as he believes it to be. Cars equipped with radar, which includes the more basic driving assistance technology, like emergency braking, would have detected the dummy.

Despite his comments on lidar, calling it a "crutch" and a "fool's errand," a Tesla was seen driving in May 2021 equipped with lidar. Around the same time, Tesla reportedly entered a partnership with Luminar to test their product in their autonomous vehicle development. Some commentators opined that it could be used to resolve certain problems Tesla faced with their other technology.¹⁴

Are these concerns fair? Is it up to Tesla to rebrand its software, or are consumers misinterpreting Tesla's messaging? One way in which Tesla has responded to these concerns over its autonomous driving capabilities is through a tweet from Musk explaining who will have access to Full Self-Driving. Since the feature does not automatically come with the purchase of a Tesla, owners must purchase the add-on and prove their driving capabilities through a driver behavior tracking tool in the car. If the driver proves they can maintain a good driving record for at least a week, they would be able to use the new Full Self-Driving.¹⁵ But is one week of perfect driving enough to allow consumers to then use the software?

Evidence of Dysfunction

On August 17, 2021, the National Highway Traffic Safety Administration (NHTSA) opened an investigation into Tesla regarding 11 incidents in which Tesla vehicles operating on

Autopilot crashed into stationary emergency response vehicles. Notably, the investigation is not limited to a certain Tesla model but instead covers Tesla models Y, X, S, and 3.¹⁶ Since the crashes have involved an array of Tesla models, we can logically assume that the issue causing these accidents is not specific to any one Tesla model and is instead, as the investigation and experts point to, with Autopilot.

To better understand the issue at hand, below are listed seven crashes in which Teslas operating on Autopilot collided with stationary emergency vehicles:

- In January 2018, a 2014 Tesla Model S struck a stopped firetruck on Interstate 405 in Culver City, California. A National Transportation Safety Board investigation found the driver was over-reliant on Autopilot and did not make any effort to prevent the crash due to his inattention. However, the investigation also found that the Tesla was able to detect the firetruck as a hazard and issued a collision warning, but not soon enough for the driver to react.¹⁷ This was the first known crash involving a Tesla operating with Autopilot crashing into a stopped emergency vehicle.
- On May 11, 2018, a Tesla Model S driving in Utah crashed into a stopped firetruck as the driver used their cell phone and failed to avoid the crash in time. After this incident, Tesla wrote that the driver was utilizing Autopilot incorrectly and that Autopilot did not detect the stopped firetruck because the Tesla manual warns drivers that not all objects may be detected and they must continue to stay alert, even while using Autopilot.¹⁸
- On May 29, 2018, a Tesla in Laguna Beach, California struck a stationary police patrol car, causing injuries to the driver and the vehicle to be totaled. Approximately two years before, another Tesla operating with Autopilot crashed into a semi-truck in the same area. In their statement, Tesla continued their messaging that drivers must remain engaged while

using Autopilot and that the autonomous driving system is only to be used on highways with clear markings and a center divider.¹⁹

- On December 7, 2019, a Tesla Model 3 crashed into a Connecticut State Police car and the vehicle the officer was attending to on Interstate 95 in Norwalk, Connecticut. While using Autopilot, the driver was turned to the backseat to check on their dog and was not paying attention to the road.²⁰
- On July 14, 2020, a Tesla Model S crashed into an Arizona Department of Public Safety patrol car around 3 a.m. on Interstate 10, resulting in the patrol car crashing into an ambulance on the scene as well. Additionally, the driver of the Tesla was found to be intoxicated at the time of the accident.²¹
- On March 17, 2021, a Tesla struck a Michigan State Police trooper who stopped responding to a collision. Police said emergency lights were activated and it was the second time in a week that Michigan State Police responded to a crash involving a Tesla using Autopilot; however, the prior incident involved the Tesla driving underneath a semi-truck, not crashing into a stationary emergency vehicle.²²
- On August 28, 2021, a Florida Highway Patrol cruiser was struck by a Tesla on an Orlando, Florida interstate highway while pulled over on the side of the road to assist a disabled vehicle, causing minor injuries to the Tesla driver and the driver of the other vehicle.²³ For reference, this incident took place *after* the official probe into Tesla was announced, hinting that the problem had not yet been fixed.

The investigation is relatively recent in bureaucratic terms and thus we can only guess what they will find. In the meantime, we ask, why are Teslas crashing into stationary emergency

vehicles? According to Carnegie Mello University electrical and computer engineering professor Raj Rajkumar, the problem likely lies within how Tesla trains its autonomous driving software.

There are essentially two different tools autonomous vehicles employ when driving: radar and cameras. Radar has been implemented in many different driver assistance systems, like detecting vehicles in a driver's blind spot or automatic emergency braking before a car crashes into an object. When we refer to radar in autonomous driving, however, we most often mean lidar. Lidar, or light detection and ranging, creates a three-dimensional model of a car's surrounding environment using lasers. Lasers pulse out from the lidar system and bounce back if they contact an object. Depending on how long the laser took to return, the computer can calculate how far the object is.

Lidar is consistently utilized in companies working on autonomous driving like Waymo, Alphabet's autonomous driving subsidiary. While lidar is successful in producing a 360-degree, three-dimensional world, it has its drawbacks. One such drawback, which has been capitalized upon by Tesla and Elon Musk, is its inability to get a visual representation of its surroundings.

Referring to Exhibit 1, this is the environment that lidar can capture. The car is aware of the various objects around it, but to the computer, they only look like shapes. Something in the image may *look* like a car, but there is no surefire way of finding out precisely what it is. Additionally, an object like a balloon and a rock may look the same in lidar and a car may overreact if it detects a balloon, whereas a human driver would be able to know a balloon will not damage the vehicle and they are likely able to run through it with no problems.

This problem is one of the main reasons Tesla is ditching the usage of the radar in its models. They argue that using cameras to map a car's surroundings is just as effective as lidar with the additional advantage of a true understanding of objects in its surroundings. Referring to the

example in the previous paragraph, the Tesla would both be able to recognize an object in its surroundings *and* whether that object was a rock or just a balloon.²⁴

Cameras function differently from lidar in that they utilize deep neural networks to identify the objects in their surroundings. Deep neural networks are essentially massive photo albums, with as many as millions of images, which provide the car's computer with different examples of what it may encounter in the real world. With the neural network, the computer matches what it observes with the cameras to the images in the network. Tesla engineers can train the car how to recognize what a car or a stop sign looks like and how to react to the image, whether it be to brake or speed up.

Given all this information, Professor Rajkumar cites the usage of the neural network as a probable explanation for some of the cases in which Tesla's are striking stationary emergency vehicles. The flashing lights of the emergency vehicles in the nighttime may have tricked the cameras into not recognizing a vehicle. Another explanation could be that the images of the emergency vehicles in one area may be different than the ones Tesla's encountered in the real world.²⁵

Professor Rajkumar's explanation could point Tesla in the right direction toward solving these issues. Training the neural network with more photos could cause Tesla's to better recognize emergency vehicles and know how to interact with them. However, not all incidents happened at night, where the lights may have tricked the neural network. Furthermore, while a firetruck certainly looks different than an ordinary passenger vehicle, most police jurisdictions utilize common car models, like Ford or Dodges.

One potential opportunity is to increase Tesla's technology of monitoring driver awareness. Before May 2021, Tesla only utilized the steering wheel to monitor driver awareness in which the

driver would have to place their hands on the wheel to show their engagement. However, a new software update allowed for the car's existing internal camera to monitor the driver's eyes and attentiveness while Autopilot is engaged.²⁶ While this does hint at a solution to one problem, it may make some users weary of privacy.

A test of this new software, however, proved to be a failure. Consumer Reports conducted a study into how effective the Tesla 'cabin cameras' were at detecting driver attentiveness. Overall, they found that drivers could still use Autopilot and Full Self-Driving even while looking at their phone and even when the camera was obscured or blocked. Tesla's cabin camera is further explained in Exhibit 2, which explains how the vehicle will provide the driver with audible alerts to maintain driver attentiveness.²⁷

Furthermore, Tesla can improve its neural network by training its computers with even more images of possible scenarios its vehicles may encounter. While the shortcomings of cameras have already been noted, there is room for growth in which Tesla can train the network with images of emergency response vehicles, flashing lights, and various other scenarios for which it has attracted media attention.

Therefore, Tesla has room to develop its technology to increase driver attentiveness and prevent unnecessary crashes. If drivers are more aware of the road, they may be more likely to notice a failure in the pilot's decision and correct the car when necessary. Furthermore, even when drivers are still inattentive, Tesla can prove they made an effort to improve their software and driver safety.

What the future holds

Tesla has been found by numerous governing bodies and courts to be falsely advertising their product. Despite having said that their Autopilot and Full Self-Driving systems are not a

replacement for human driving and only act as a supplement, other indications from the company may hint otherwise.

Evidently, the network of Tesla vehicles was likely not trained with the correct images it needed to avoid crashes with autonomous emergency vehicles. Given the repetition of incidence, the NHTSA found it adequate to conduct a study into why Teslas were repeatedly crashing into these vehicles. A common theme in the incidents, however, was driver inattentiveness.

Many industry experts believe Tesla is an outlier, and perhaps making a mistake, by ditching all forms of the radar in their vehicles and relying strictly upon cameras. Given the advancements made in camera technology, Musk and Tesla believe their strategy will pay off. However, if lidar proves to be a success for Tesla's competitors, regulatory agencies may place high scrutiny on Tesla, causing even further drama.

If Teslas had lidar, would these crashes have occurred? Is it Tesla's responsibility that its vehicle owners are not paying attention to the road? Perhaps if they remarketed Autopilot, fewer consumers would place as much trust in it. This begs the question again, is Tesla responsible for consumers failing to read the fine print? Only time will tell whether Tesla can be found for wrongdoing in emergency vehicle collisions. Furthermore, only time will tell whether Tesla truly meets what it says it is, or whether it will eventually fall behind.

Exhibit 1: The World Seen Through Lidar

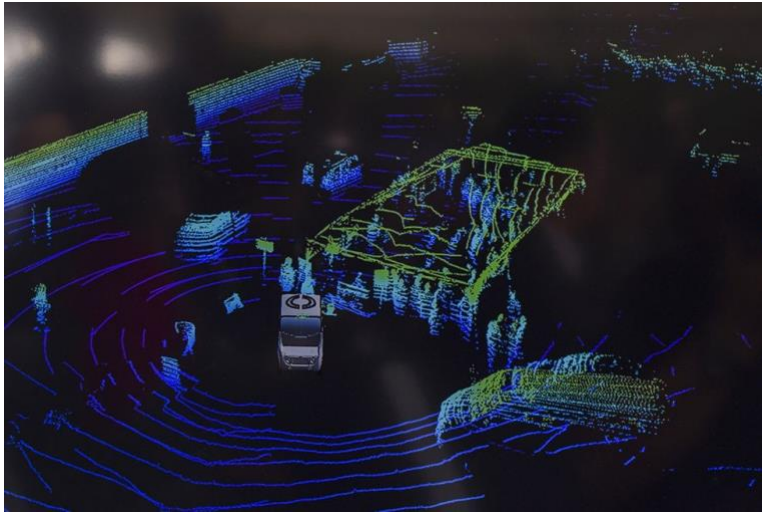
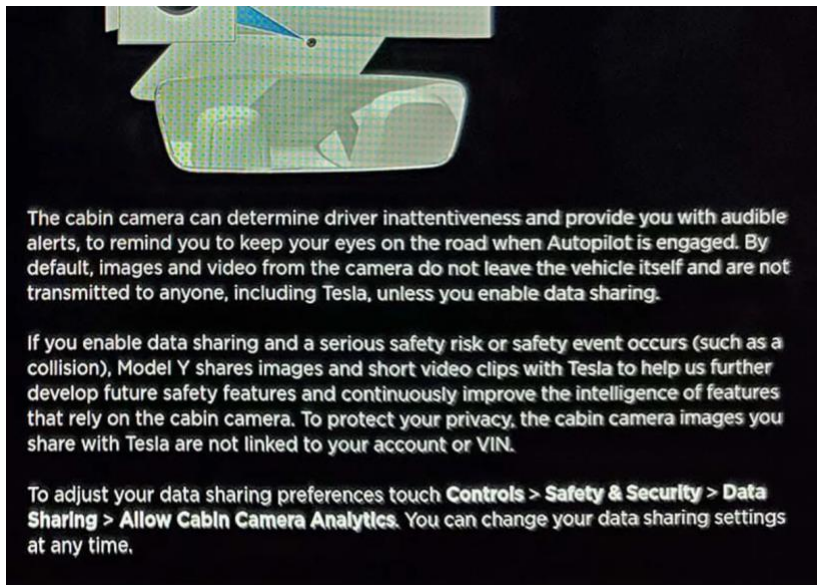


Exhibit 2: Tesla Cabin Cameras



Endnotes

1. Clifford, Catherine. "Elon Musk: This Is the 'Why' of Tesla." CNBC. CNBC, February 4, 2019. <https://www.cnbc.com/2019/02/04/elon-musk-on-the-why-and-purpose-behind-tesla.html>.
2. Levin, Tim. "‘Absolutely Brilliant’: An Auto-Manufacturing Expert Praised Tesla's Latest Self-Driving Software after a Test Ride." Business Insider. Business Insider, February 13, 2021. <https://www.businessinsider.com/tesla-fsd-elon-musk-sandy-munro-self-driving-beta-reaction-2021-2>.
3. Hayden, Tyler. "Santa Barbara Brothers Accuse Tesla of False Advertising." The Santa Barbara Independent, July 22, 2021. <https://www.independent.com/2021/07/22/santa-barbara-brothers-accuse-tesla-of-false-advertising/>.
4. "Autopilot and Full Self-Driving Capability." Tesla, February 25, 2022. <https://www.tesla.com/support/autopilot>.
5. Clifford, Catherine. "Elon Musk: This Is the 'Why' of Tesla." CNBC. CNBC, February 4, 2019. <https://www.cnbc.com/2019/02/04/elon-musk-on-the-why-and-purpose-behind-tesla.html>.
6. Newman, Rick. "It's Time to Notice Tesla's Autopilot Death Toll." Yahoo! News. Yahoo!, April 19, 2021. <https://news.yahoo.com/its-time-to-notice-teslas-autopilot-death-toll-195849408.html>.
7. Associated Press. "A Tesla Driver Is Charged in a Crash Involving Autopilot That Killed 2 People." NPR. NPR, January 18, 2022. <https://www.npr.org/2022/01/18/1073857310/tesla-autopilot-crash-charges>.
8. "Blumenthal & Markey Call for FTC Investigation into Tesla's Misleading Advertising of Driving Automation Systems: U.S. Senator Richard Blumenthal of Connecticut." U.S. Senator Richard Blumenthal, August 18, 2021. <https://www.blumenthal.senate.gov/newsroom/press/release/blumenthal-and-markey-call-for-ftc-investigation-into-teslas-misleading-advertising-of-driving-automation-systems>.
9. Wayland, Michael. "NTSB Head Criticizes Tesla's Self-Driving Features, Calls Them 'Misleading'." CNBC. CNBC, October 27, 2021. <https://www.cnbc.com/2021/10/26/ntsb-head-criticizes-teslas-self-driving-features-calls-them-misleading.html#:~:text=The%20head%20of%20the%20U.S.,its%20latest%20systems%20%E2%80%9Cmisleading.%E2%80%9D>.
10. Shead, Sam, and Lora Kolodny. "German Court Rules That Tesla Misled Consumers on Autopilot and Full Self Driving." CNBC. CNBC, July 14, 2020. <https://www.cnbc.com/2020/07/14/tesla-autopilot-self-driving-false-advertising-germany.html>.
11. "Transitioning to Tesla Vision." Tesla, February 28, 2022. <https://www.tesla.com/support/transitioning-tesla-vision>.
12. Metz, Cade, and Neal E Boudette. "Inside Tesla: How Elon Musk Pushed His Vision for ..." The New York Times. The New York Times, December 7, 2021. <https://www.nytimes.com/2021/12/06/technology/tesla-autopilot-elon-musk.html>.
13. Stumpf, Rob. "This Tesla Model Y Dummy Crash Shows Exactly Why Lidar Matters." The Drive. The Drive, January 7, 2022. <https://www.thedrive.com/tech/43779/this-tesla-model-y-dummy-crash-shows-exactly-why-lidar-matters>.
14. Hawkins, Andrew J. "Elon Musk Called Lidar a 'Crutch,' but Now Tesla Is Reportedly Testing Luminar's Laser Sensors." The Verge. The Verge, May 24, 2021.

-
- <https://www.theverge.com/2021/5/24/22451404/tesla-luminar-lidar-elon-musk-autonomous-vehicles>.
15. Heilweil, Rebecca. "Elon Musk's Problematic Plan for 'Full Self-Driving' Teslas." Vox. Vox, May 12, 2021. <https://www.vox.com/recode/22425169/autonomous-features-cars-elon-musk-autopilot>.
 16. Boudette, Neal E, and Niraj Chokshi. "U.S. Will Investigate Tesla's Autopilot System over Crashes with Emergency Vehicles." The New York Times. The New York Times, August 16, 2021. <https://www.nytimes.com/2021/08/16/business/tesla-autopilot-nhtsa.html>.
 17. Krisher, Tom. "NTSB: Autopilot Flaw, Driver Inattention Caused Tesla Crash." AP NEWS. Associated Press, September 4, 2019. <https://apnews.com/article/transportation-technology-mi-state-wire-transportation-ca-state-wire-technology-868ef90731034afdb364fc268cccd33>.
 18. Levin, Sam. "Tesla Confirms Autopilot Involved in Utah Crash but Seeks to Blame Driver." The Guardian. Guardian News and Media, May 17, 2018. <https://www.theguardian.com/technology/2018/may/16/tesla-autopilot-utah-crash-confirms-investigation>.
 19. KTLA 5. "Tesla on Autopilot Crashes into Laguna Beach Police Vehicle." FOX 5 San Diego. FOX 5 San Diego, May 30, 2018. <https://fox5sandiego.com/news/tesla-on-autopilot-crashes-into-laguna-beach-police-vehicle/>.
 20. Torres, Ella. "Tesla on Autopilot Slams into Police Cruiser, Driver Claims He Was Checking on His Dog." ABC News. ABC News Network, December 7, 2019. <https://abcnews.go.com/US/tesla-autopilot-slams-police-cruiser-driver-claims-checking/story?id=67570199>.
 21. Minkler, Alana. "Tesla on Autopilot Crashes into DPS Patrol Car on I-10." The Arizona Republic. Arizona Republic, July 15, 2020. <https://www.azcentral.com/story/news/local/arizona-breaking/2020/07/14/tesla-autopilot-hits-dps-patrol-car-10-near-benson/5439368002/>.
 22. Associated Press. "Tesla on Autopilot Drives into Michigan Trooper's Patrol Car." ABC News. ABC News Network, March 17, 2021. <https://abcnews.go.com/US/wireStory/tesla-autopilot-drives-michigan-troopers-patrol-car-76524732>.
 23. Associated Press. "Tesla on Part-Automated Drive System Slams into Police Car." <https://www.wagmtv.com>, August 28, 2021. <https://www.wagmtv.com/2021/08/28/tesla-part-automated-drive-system-slams-into-police-car/>.
 24. Teague, Chris. "What Lidar Is and Why It's Important for Autonomous Vehicles." Autoweek. Autoweek, December 22, 2021. <https://www.autoweek.com/news/a36190274/what-lidar-is/>.
 25. Mak, Aaron. "Why Teslas Keep Striking Parked Firetrucks and Police Cars." Slate Magazine. Slate, August 17, 2021. <https://slate.com/technology/2021/08/teslas-allegedly-hitting-emergency-vehicles-why-it-could-be-happening.html>.
 26. "Tesla Cameras Will Monitor Driver Awareness." BBC News. BBC, May 28, 2021. <https://www.bbc.com/news/technology-57283479>.
 27. Barry, Keith. "Tesla's Camera-Based Driver Monitoring Fails to Keep Driver Attention on the Road, CR Tests Show." Consumer Reports, January 15, 2022. <https://www.consumerreports.org/car-safety/tesla-driver-monitoring-fails-to-keep-driver-focus-on-road-a3964813328/>.