

Proposal to Investigate Regulation and Standardization of Continuous Data Collection in Autonomous Vehicles (AVs) to Ameliorate the Incidence of AV Accidents

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Abstract:

The purpose of this research is to make policy recommendations regarding autonomous vehicle (AV) accident investigations. We first give examples of recent fatal AV accidents and the investigative findings regarding the crashes. We then go into detail about the main

kinds of AV technologies, defining exactly what an AV is, and then lead into our recommendations on policy regarding Electronic Data Recorders (EDRs) to improve data collection and analysis after a collision. We later describe how accident investigations are currently handled and then policy recommendations regarding to how to deal with a potential increase in AV crashes at the federal level, due to the increasing number of cities and states that will allow AV testing. The National Highway Traffic Safety Administration (NHTSA) and the National Transportation Safety Board (NTSB) have already detailed much of this; our recommendations are an expansion on the existing laws and safety guidelines.

Introduction:

While autonomous vehicles (AVs) have the potential to drastically reduce the number of accidents that occur on our roads, the accident count will never go all the way to zero. There are far too many edge cases for autonomous systems to deal with: for example, extreme weather conditions, poor behavior of other manually-controlled vehicles, and obstructions on the road like fallen trees or construction (not to mention bugs in the software). Furthermore, humans are the cause of most AV-related accidents¹. Since we cannot expect AVs to replace conventional vehicles overnight, it is likely that an increase in testing of AVs will lead to more AV-related crashes. Although there are several areas of policy regarding AVs that should be of concern to lawmakers, this paper is primarily concerned with autonomous vehicle accidents during testing and when this technology becomes commercialized — both on how to mitigate accidents using data collection during operation and how states and the federal government should go about regulating and conducting accident investigations if and when AVs become more widespread in the U.S.

It is important for state and federal policies to have foresight when new technologies like self-driving cars have the potential to jeopardize the safety of individuals, even when they are intended to improve safety in the long-run. Our policy recommendations are intended to be proactive so as to be prepared for future incidents of autonomous vehicle accidents. We will first discuss a couple well-known accidents regarding autonomous vehicles and how their respective investigations were conducted. We will then go into detail on current AV technology, leading into our recommendations for how data should be collected and uploaded for accident investigations. We will then make policy recommendations regarding investigations for the federal level.

Examples of Fatal Autonomous Vehicle Crashes:

Tesla - Williston, Florida

In May 2016, a Tesla Model S with a backup driver collided with a tractor trailer that was crossing an intersection, resulting in fatal injuries to the backup driverⁱⁱ. The car's sensors failed to distinguish the white truck from the bright sky behind it, and ultimately did not recognize the truck as an obstruction. The car attempted to pass underneath the truck, but the windshield was smashed by the underside of the truck, killing the driver.

The National Highway Traffic Safety Administration (NHTSA), an agency of the Executive Branch, and the National Transportation Safety Board (NTSB), an independent U.S. government investigative agency in charge of autonomous vehicle accident investigations, both conducted investigations on this incident. The NHTSA closed their investigation saying that they had not discovered an issue with Tesla's Autopilot system, essentially blaming the driver for having at least 7 seconds to respond by breaking or steering but seemed to be distracted. The NTSB also conducted an investigation and their report contained no conflicting information with the NHTSA's report. They also claimed the driver received several visual messages telling him to put his hands back on the wheelⁱⁱⁱ.

While the crash may have been partially the fault of backup driver, Tesla's autopilot system did not recognize the obstruction and therefore did not instruct the vehicle to slow down. It was clearly an issue with the sensors and software interface that led to the death of the driver.

Uber – Tempe, Arizona

In March 2018, a self-driving Uber car with a backup driver at the wheel was involved in a fatal crash in Tempe, Arizona, killing a 49-year old woman. The NTSB released a preliminary report detailing the issues that led to the crash.^{iv} According to the report, the sensors had noticed the pedestrian approximately 6 seconds before the impact- so it had plenty of time to respond but ultimately did not. At 1.3 seconds before the crash, the system determined that an emergency break was needed to reduce possibility of impact; however, an emergency break was not enabled while the vehicle was under computer control so as to "reduce the potential for erratic vehicle behavior." The backup driver was relied upon to take action and intervene if necessary, but the system was not designed to

alert the operator when these situations arose — the operator ended up seizing control of the steering wheel less than a second before the impact, and began breaking. According to the report, the vehicle speed at impact was 39 mph and there were no faults or diagnostic messages displayed by the system at the time of the crash.

Uber is at fault here for many reasons. Not only did their software not respond to a pedestrian it had identified, but there were also issues with the system's inability to alert the backup driver to take control, as well as the lack of emergency break to operate during computer control.

[How to Address Autonomous Vehicle Crashes](#)

These accidents should be warning enough that legislation needs to do more in regulating AV companies and the testing process. Also, establishing stricter protocols for the testing process can serve as a foundation for law once autonomous vehicles start deploying for commercial purposes and public use. Fortunately, there are common-sense solutions to these issues that involve policy: for example, federal government can mandate that self-driving vehicles with backup operators must be notified by autonomous systems to take the wheel if necessary, emergency breaking should be functional at all times, etc. While this paper does not focus on policy AV testing, it does focus on the need to standardize both the data that must be collected and available for accident investigation, as well as what governmental bodies should be involved in the process of overseeing the potential increase in number of AV accidents and regulation as AVs become more widespread. Later in this paper, We will detail what kinds of parameters should be collected during operations, so that proper investigations can be conducted of autonomous vehicle collisions.

Autonomous vehicles will likely never be perfect, but more and more are being tested on our roads every year, and they will likely be available to the public in the near future. The federal and state governments must start being proactive about how AVs will affect our cities and roads, while simultaneously not hindering innovation in this area of transportation. Our policy recommendations are aimed to be the least regulatory as possible so as to not discourage manufacturers from being inventive. We believe that our policy recommendations are simply common sense suggestions, building from what the federal government has already mandated. We hope that our recommendations and future implemented policy regarding AVs contributes to the safety and well-being of pedestrian, bicyclists, and other drivers on the road who are unwitting participants of the testing of AVs.

Background on AV technologies:

Before we go into detail regarding our policy recommendations concerning AVs at a more technical level, it is helpful to give some background on AV technology itself. Many commercial vehicles have automated functions like parallel parking assistance, blind spot detection, and collision mitigation braking systems. The NHTSA has developed a five-part continuum on AV technology's different levels of automation and their respective benefits^v:

- **Level 0:** No automation — zero autonomy; the driver performs all driving tasks.
- **Level 1:** Driver assistance — vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.
- **Level 2:** Partial automation — vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.
- **Level 3:** Conditional automation — Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.
- **Level 4:** High automation — the vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.
- **Level 5:** Full automation — the vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

When the average person sees or hears of autonomous vehicles being tested on the road by companies like Tesla, Uber, and Waymo, these vehicles generally fall under Levels 2 and 3. The end-goal for most of these companies is to eventually deploy Level 5 vehicles. Waymo (owned by Google) has recently been granted permission to deploy fully autonomous vehicles^{vi} in certain areas, without a human driver, in the Mountain View area in California, making the vehicle most likely fall under the Level 4 category.

Our policy recommendations in this paper will be applicable to all vehicles from levels 2 to 5.

How do autonomous vehicles work?

Autonomous vehicles sense their surroundings mainly using a combination of three technologies: LiDAR, radar, and cameras. We will discuss how each technology works, including its pros and cons, and what technologies the most well-known AV companies are currently using.

LiDAR – LiDAR (Light Detection and Ranging) is the technology that is used by most major AV companies. The technology uses lasers to send out millions of pulses of light per second, and then measures the amount of time it takes for the light to bounce off an object and return to the sensor. It can then calculate the distance from the object to the vehicle^{vii}. The device is usually placed on top of cars and is then able to map a 360 degree view of its surroundings. It can generate a precise three-dimensional rendering of the object, regardless of whether it is a pedestrian or a mountain. The technology has been around for decades, but has gotten so advanced that it is able to tell which direction a pedestrian is facing and predict which way it will walk. Waymo uses LiDAR, and its technology allows the detection of hand signal from bicyclists which then allows to vehicle to make decisions accordingly^{viii}.

There are a few downsides to LiDAR, however. LiDAR is one of the more expensive technologies AVs use compared to Radar and cameras. Uber currently use Velodyne's sensor^{ix}, which costs around \$80,000^x. LiDAR systems also contain moving parts, creating more chances for error. Fog and snow also inhibit the sensor, so for the moment LiDAR's capabilities are weather dependent

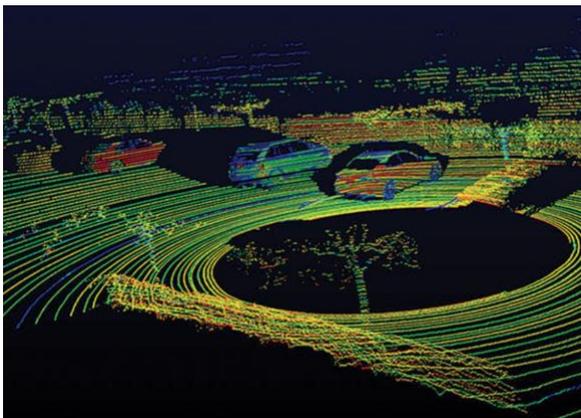


Figure 1: Example of LiDAR's perception of its surroundings (<https://spectrum.ieee.org>)

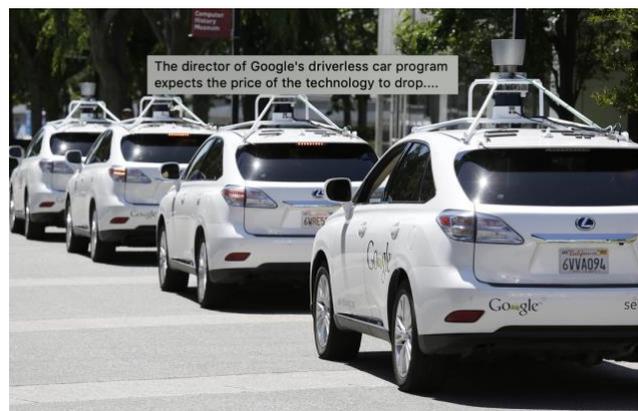


Figure 2: LiDAR units on top of Waymo cars (<https://wsj.com>)

Radar – Radar works similarly to LiDAR, but it sends out radio waves instead of light. Radio can pass through snow and fog, making it more resistance to interference during adverse weather conditions. Radar also works identifying objects as much farther distances than other technologies because the waves have less absorption compared to light waves when they come into contact with objects^{xi}. However, it is not as sensitive as LiDAR to smaller objects, and is generally used to identify larger objects like cars^{xii}.

Camera Systems – Some companies choose to be more dependent on cameras for their perception systems. Vehicles generally use multiples cameras placed at different angles to provide the autonomous system a 360 degree view of their surroundings. The two-dimensional images provided by the cameras is then run through computer vision algorithms that creates a three-dimensional mapping of the vehicle’s environment. Cameras systems have the advantages of being able to see lane marking , read road signs, and identify colors^{xiii}. The cameras themselves are also fairly cheap, although processing power is more costly (but still not as expensive as LiDAR and most radar systems). However, there are downsides to using systems made up only of cameras. These systems struggle in poor weather conditions, since rain and fog can block the vehicle’s surroundings from the camera sensors. For this reason, companies often use camera systems in conjunction with LiDAR or radar for the added benefits of increased accuracy in depth perception and ability to perform better in diverse weather conditions.

What technologies do most companies use?

These technologies have their pros and cons, and companies have optimized accuracy when imaging their environments by placing combinations of these technologies in their vehicles.

Most companies including Waymo, Uber, and Cruise Automation (owned by General Motors) use a combination of LiDAR, radar, and camera systems for their perception systems^{xiv}. And furthermore, each company purchases LiDAR, radar, and camera systems from a variety of manufacturers. Tesla is one of the few companies that has eschewed using LiDAR, and has cited cost and the bulkiness of the technology as reasons for doing so^{xv}. They instead use cameras and radar for their perception systems.

The overview of technologies used by AV companies in this paper is meant to make clear that it will be difficult to address each technology itself when creating legislation, because each company uses widely different methods to perceive the vehicle’s surrounding

environments. It is best to write regulations that are not technology-dependent, for the reasons that it is simply too difficult to encompass the diversity in technology when thinking about accident investigation efficiency, and also because our and the NHTSA's regulations are not meant to inhibit innovation by AV manufacturers by placing rules on the technology itself, and furthermore inhibit innovation by the various manufacturers of LiDAR, radar, and camera systems. In the next section of this paper, we will address what kinds of data the federal government should mandate during being collected during operation of these vehicles and how it should be done. The suggested parameters will not be technology dependent so that we are avoiding regulating the technology itself, and we are therefore able to specify the data we want regardless of the technology the vehicle uses.

Proposal for Regulating Data Collection and Transfer of Data:

In order for external investigations to run as smoothly and efficiently as possible, we suggest NHTSA mandates the AVs to collect and store certain kinds of data that can be made available to investigative committees after an accident. The NHTSA already has some regulations in place, but we suggest stricter regulations in this paper that should apply to all AVs. Here, we will go into detail on how that should be done and what kinds of data should be tracked and saved during the operation of AVs, and importantly, specify a format in which this data must be saved so that investigative committees will be able to easily analyze the cause of the accident.

The NHTSA has coined the term "Event Data Recorders" (EDRs) to refer to the device most vehicles have installed which collects information for a brief period of time in the event of an accident. EDRs differ from flight recorders, or black boxes, in aircrafts (which are regulated by the International Civil Aviation Organization) in that they only save information in the occurrence of an accident, while flight recorders collect and save data continuously during the vehicle's operation. Most EDRs only record data around the time of an accident.

EDRs and flight recorders have been around for decades. Currently, over 90% of new cars sold in the United States have some form of EDRs installed^{xvi}. However, the installation of them is completely voluntary by the manufacturers. The NHTSA has regulations in place concerning those who choose to install EDRs. There are currently 15 data points that are mandated if the manufacturer chooses to install an EDR which includes speed at impact,

whether the brakes were applied, and whether seat belts were used^{xvii}. The NHSTA requires this data be saved in a particular format:

Required Essential Data Elements and Formats

Item #	Data Elements	Recording Time*	Sampling Rate	Range	Accuracy	Resolution	Filter
1	Delta-V, Longitudinal	0 – 250 ms	100/s	-100 to 100 km/h	± 5%	1 km/h	N.A.
2	Maximum delta-V, Longitudinal	0 – 300 ms	N.A.	-100 to 100 km/h	± 5%	1 km/h	N.A.
3	Time, Maximum delta-V, Longitudinal	0 – 300 ms	N.A.	0 – 300 ms	± 3 ms	2.5 ms	N.A.
4	Speed, vehicle indicated	-5.0 to 0 s	2/s	-200 to 200 km/h	± 1 km/h	1 km/h	N.A.
5	Engine throttle, % full (accelerator pedal % full)	-5.0 to 0 s	2/s	0 – 100%	± 5%	1%	N.A.
6	Service brake, on/off	-5.0 to 0 s	2/s	On/off	N.A.	N.A.	N.A.
7	Ignition cycle, crash	-1.0 s	N.A.	0 – 60,000	± 1 cycle	1 cycle	N.A.
8	Ignition cycle, download	At time of download	N.A.	0 – 60,000	± 1 cycle	1 cycle	N.A.
9	Safety belt status, driver	-1.0 s	N.A.	On/off	N.A.	On/off	N.A.
10	Frontal air bag warning lamp	-1.0 s	N.A.	On/off	N.A.	On/off	N.A.
11	Frontal air bag deployment time, Driver (1 st stage, in case of multi-stage air bags)	Event	N.A.	0 – 250 ms	±2 ms	1 ms	N.A.
12	Frontal air bag deployment time, RFP (1 st stage, in case of multi-stage air bags)	Event	N.A.	0 – 250 ms	±2 ms	1 ms	N.A.
13	Multi-event, number of events (1 or 2)	Event	N.A.	1, 2	N.A.	1, 2	N.A.
14	Time from event 1 to 2	As needed	N.A.	0 - 5.0 s	0.1 s	0.1 s	N.A.
15	Complete file recorded (yes or no)	After Other Data	N.A.	Yes/no	N.A.	Yes/no	N.A.

s: second; ms: millisecond; km/h: kilometer per hour; RFP: right front passenger; N.A.: not applicable

* Relative to time zero

The NHTSA also requires up to 30 additional parameters to be recorded if the vehicle containing an EDR has the capability to acquire this data. These data elements include (generally from time a couple seconds before event until impact) steering wheel angle, seat position of the driver, engine RPM, and vehicle roll angle.

We recommend that NHTSA mandates that all AVs from Levels 2–5 that contain airbags should have Event Data Recorders (EDRs), as well as buses and heavy duty vehicles that fall under these automation categories. And furthermore, the data points^{xviii} that are already mandated are incredibly useful for accident investigation, but we believe more kinds of parameters should be collected to more efficiently conduct accident investigations. **Along with the parameters that the NHTSA already mandates, we suggest they mandate the collection of data, if the vehicle is capable of acquiring this**

data, concerning all vehicles and pedestrians the AV identifies in its path, and specify how the software classifies the object (such as bicycle, pedestrian, another vehicle, etc.) as well as their estimated locations with respect to the vehicle (specifying a reference point on the vehicle) and estimated speeds and directions they are moving in. The output format is specified in Table 1.

With these additional data points, we believe if the investigation agencies are given access to this data, they will better be able to create their own picture of how the accident occurred, and therefore will be able to conduct external regulations with more efficiency and will not have to ask and receive data from the companies that might be in a format difficult to extract useful information from. While the data collection we have suggested may not be sufficient to completely determine accident causes in all cases, there is a trade-off between company privacy and efficient accident investigation. We will discuss more about privacy-related issues at the end of this section.

It is unreasonable to expect vehicles to store this information from the beginning of operation, or when the engine turns on. There will simply be too many data points and require huge amounts of storage space, putting an undue burden on manufacturers of EDRs. **Therefore we suggest that vehicles do monitor this information continuously, but only store the last two minutes of information in the EDRs and override data that goes farther back than the two minute limit.** Not only should they save the last two minutes, but they should **save data at a rate of at least 4 Hz** or every 0.25 seconds. According to the paper by the Swedish National Road and Transport Research Institute, modern vehicles can collect data up to 10 Hz, so “a 4 Hz limit is not an excessive burden”^{xix}.

When the event of the vehicle making contact with another object occurs, this should trigger the EDR to stop overriding the data — essentially, the EDR should have saved this data two minutes leading up to the accident. **From the moment of impact until the vehicle stops moving, the EDR should continue to record and save the same parameters** in addition to the previously saved two minutes of data.

These parameters would be collected along with the NHTSA’s current mandate of the 15 parameters. The NHTSA has specified data collection time lengths and frequencies if an accident occurs. We will not be suggesting changing the length of time here or other changes to this current mandate, because these parameters are specifically crash related (such as deceleration rate and airbag deployment time). We believe the current regulations are sufficient for third party accident investigation. However, the additional parameters we

have proposed will provide investigators with a better picture of the vehicle’s surroundings leading up to the accident (which we believe the current regulations are lacking), along with the accident data itself already specified by the NHTSA.

While two minutes of recorded data might seem like an arbitrary time, it is a trade-off between storage space and information. Obviously, the more data investigative committees have, the better. However, it is generally safe to say that two minutes of data starting from the crash — the vehicle coming in contact with another object — is sufficient for encapsulating both data from the accident and the related information leading up to the accident.

While most AV software already collects this data we have specified since this is necessary in order for the vehicle to make decisions, different manufacturers likely store and format this information in various ways. Simply collecting and storing the raw data is generally unusable for third party investigators who may not be aware of identifiers and data points the code outputs, particularly if the output is binary code. A standardized output is necessary for investigators to make sense of the data:

Table 1: Suggested Parameters for AV Data Collection with Example Data

Timestamp	Vehicle Reference Point	Object Classification	Object Position from Ref Point (degrees)	Object Distance from Ref Point (m)	Estimated Movement Direction of Object (degrees)	Estimated Speed of Object (m/s)
-35.5s	Middle of front bumper	Car	330	8	90	16
		pedestrian	85	5.3	20	1.4

Timestamp: This data will be saved from two minutes prior to the event, the impact of the vehicle with another object, and will continues to be recorded until the vehicle stops moving. Data will be saved at a rate of 4 Hz.

Vehicle reference point: Specifies a point on the vehicle at which other parameters are calculated from. Can be anywhere on the vehicle as long as clearly noted.

Object Classification: Specifies the type of object detected by the perception system. Should be as specific as the software is able to identify. Examples include, car, bus, pedestrian, motorcycle. All objects identified and their corresponding data must be displayed at any given timestamp.

Object Position From Reference Point: Denotes the angle at which object identified is located from the reference point on the vehicle. The polar coordinate system is used: to the right is 0 degrees, straight ahead is 90 degrees, etc.

Object Distance From Reference Point: Denotes radial distance of closest point on detected object to vehicle reference point.

Estimated Movement Direction of Object: Denotes estimated direction of movement of identified object in degrees, with respect to vehicle's own coordinate system.

Estimated Speed of Object: Denotes the estimated speed of the identified object.

With the variety of technology being used in AVs that varies from company to company, it is difficult to write legislation that fully takes into account the nuances of each technology. Therefore, our proposed regulations are not technology-specific, but rather mandates the collection and transfer of certain kinds of data most vehicles are likely doing already, and presents it in a format that is usable for investigative committees. Considerations like requiring upload of camera data and/or radar and lidar data were considered for this paper, but ultimately the diversity in technology would likely lead to confusion regarding standardized outputs across all manufacturers and might hinder companies from using certain kinds of technologies. Requiring and standardizing camera data would also lead to confusion, since different companies have various numbers of cameras and place them in diverse locations. There may also be privacy concerns regarding camera data, since mandating the collection and transfer to investigative party might lead to identification of certain people in the vehicles' line of sight. We also considered mandating displaying system decisions (such as breaking, changing directions) in the event of an accident, but the data points already mandated by the NHTSA contain steering wheel angles and whether or not the brakes were applied, including the timestamp, and we thought these would be sufficient in determining how the vehicle's software and hardware responded in this event.

Data Extraction

EDR locations within vehicles are currently left to the discretion of manufacturers, but are generally placed in well-protected areas of the vehicle so that they are likely to survive an accident (although they have several sensors that are located throughout the vehicle that perform different functions)^{xx}.

The NHTSA currently states that “each manufacturer of a motor vehicle equipped with an EDR shall ensure by licensing agreement or other means that a tool(s) is commercially available that is capable of accessing and retrieving data stored in the EDR that are required by this part. The tool(s) shall be commercially available not later than 90 days after the first sale of the motor vehicle for purposes other than resale.”^{xxi}

The current extraction process is still applicable with our additional suggested parameters. We will not be suggesting alternative methods of data extraction because we think standardizing the process for data extraction may hinder the innovation of extraction tools and EDRs themselves.

Privacy concerns:

Manufacturers and vehicle owners have the concern that requiring collection of certain kinds of data might infringe upon rider and company privacy.

In 2015, President Obama signed into law the Driver Privacy Act. The law ensured that the information contained within an EDR cannot be freely accessed by anyone other than the owner or lessee. There are a few exceptions including^{xxii}:

- 1) as authorized pursuant to a court authority subject to standards of admissible evidence
- 2) pursuant to the written, electronic, or recorded audio consent of the vehicle owner or lessee
- 3) to carry out investigations pursuant to federal law
- 4) to determine the need for, or facilitate, medical care in response to a car accident
- 5) for traffic safety research, as long as the personal information of the owner/lessee is not disclosed.

The NTSB can gain access to EDR information since they carry out federal investigations, but in most other cases it is necessary to first get permission from the vehicle owner/lessee before downloading the EDR data.

Unlike flight recorders that collect audio and video, the NHTSA mandates as well as our proposal for data collection do not require EDRs to contain any personal identification information. However, the vehicle identification number may be required to download information from the EDR^{xxiii}.

Furthermore, the information we and the NHTSA have asked of AV companies will not expose the trade secrets of these companies, which is important for maintaining competition and innovation in this field. We specifically chose parameters that vehicles will be collecting anyway, regardless of whether they use cameras, LiDAR, radar, or any other kinds of sensors. The standardized format of the outputs and the information we ask for are not relevant to any specific kind of technology, and therefore company secrets will not be compromised by this regulation.

Other privacy concerns regarding EDRs are valid and significant. Insurance companies are already incentivizing consumers to install or purchase vehicles with EDRs by charging reduced rates^{xxiv}. However, the trade-off here is the reduction in privacy since insurance companies use the data from EDR to calculate premiums. Customers are beginning to face a catch-22 situation by either choosing a loss of privacy or higher insurance premiums. Our proposal as well as future potential regulation by the NHTSA will likely exacerbate this situation by giving consumers no choice but to own or lease vehicles containing EDRs, and therefore are subject to a loss of privacy from insurance companies. However, since most new vehicles contain EDRs, this proposal will not make the situation much worse.

While in most cases we believe that privacy should be of the utmost concern to consumers and companies, these regulations we have suggested will promote more efficient accident regulation and lead to fewer injuries and loss of life. We believe the regulations given by the agency as well as our additions are justified, and in this case worth the trade-off for loss of privacy since the information provided will be invaluable to parties conducting crash investigations.

Recommendation on how to improve AV crash investigation:

The NTSB (National Transportation Safety Board) is an independent U.S. government agency that is responsible for investigation civil transport accident investigation. They were established by Congress in 1967, first place within the Department of Transportation and then reestablished as a separate and independent entity, with the intent of effectively promoting a higher level of safety in transportation, and has since investigated accidents in the aviation, highway, marine, pipeline, and railway modes. They also issue safety recommendations, but do not have the formal authority to regulate the transportation industry. They claim that their “effectiveness depends on our reputation for conducting thorough, accurate, and independent investigations and for producing timely, well-considered recommendations to enhance transportation safety.”^{xxv}

How do NTSB investigations currently proceed?

NTSB’s skill and dynamism in conducting accident investigations is due to their “Go Team.” The Safety Board Go Team is composed of three to twelve specialists from the Board’s headquarters in Washington D.C. who are assigned on a rotational basis to respond as quickly as possible to the scene of an accident^{xxvi}. Each specialist on the team is responsible for a defined portion of the investigation. In the case of an aviation accident, the specialties include weather, human performance, operations, systems, etc. Each investigator is the head of a working group in their area of expertise, and these groups are made up of representatives of parties to the investigation such as the vehicle and part manufacturers. Further groups can be created at the accident scene, such as vehicle performance, maintenance records, and eyewitnesses. Specialist for highway crashes include a truck or bus mechanical expert and highway engineers.

The working groups remain at the accident scene as long as necessary, which could be from a few days to several weeks. They then return to D.C., and begin analysis and drafting a proposed report that goes to the Safety Board itself about 12 to 18 months after the accident date. They can issue safety recommendations at any time during the course of the investigation.

The NTSB designates other organizations and external parties to participate in its investigations to create a well-rounded investigation that covers the bases of information

that the NTSB might be deficient in. This “party system” has become integral to the NTSB since transportation systems have become more multifaceted and organizations more interconnected. The NTSB exercises complete control over which organizations it designates as a party in the investigation. In fact, they removed Tesla as a party to their investigation of a Tesla Model X fatal crash in Mountain View in March 2018 because Tesla released investigative information before it was approved by the NTSB^{xxvii}.

One of the most important results of the NTSB’s investigations is their accident reports. Each report produced is generally concerned with a specific accident (in the case of AV investigations). Reports generally discuss events leading up to the accident, states of the driving systems, and probable causes of the accident only after the analysis is completed.

[How to address AV accident investigation in the future as road testing and deployment get more popular:](#)

There are currently at least 30 U.S. cities that have AV testing programs underway, and dozens more are preparing to address how AVs will impact their cities by planning and enacting legislation^{xxviii}. And in California since 2014, there have been about 38 AV-related accidents in which the AVs were moving while in autonomous mode and driving on their own. However, only in one case was the accident caused by the technology itself; the rest of the accidents were caused by humans (for example, a driver rear ending the AV). There were also 24 accidents in which the AV had stopped moving, but all cases were because of human error^{xxix}.

It is likely that even as self-driving technology gets closer to faultlessness, humans error will still cause many accidents involving AVs. We cannot expect AVs to replace all manually driven cars overnight, so AVs and conventional vehicles must coexist on our roads. It is also likely that AV technology will never be completely perfect. And since more and more cities and states are planning to allow AV testing and we can expect in the near future for these vehicles to exist as a natural part of our cities, we must begin thinking about ways to conduct accident investigation efficiently as the number of AV-related incidents are likely to increase.

Of course, it is impossible to predict the accident likelihood of AVs once the technology becomes more widespread at this time, especially when this technology is still only being tested in a handful of cities across the U.S. The recommendations we are putting forth

concern hypothetical scenarios assuming that AVs become more and more common on our roads, and the accident count too burdensome for the NTSB to handle if it continues its practices in its current form.

There are a few ways in which we can think accident investigations and the NTSB can adapt to the increasing number of AV accidents:

- 1) Increase the number of “Go Team” members specifically for AV-related incidents. According to the NTSB website, the same teams that handle airline crashes also handle other investigations concerning highway, marine, and pipeline incidents. If the number of AV crashes increases significantly in the future, it might be beneficial to have multiple teams available at any time (still on a rotational basis) that are trained specifically for these kinds of accidents.
- 2) Consider having regional NTSB labs and offices across the U.S. and have Go Teams designated for these offices. Having localized teams would decrease the response time to accidents and would more efficiently address accidents that are within the range of the individual offices. Offices and labs could be placed judiciously so that each region contains a similar number of AVs. Of course, the number of regional offices and Go Teams needed would be entirely dependent on accident rates and the concentrations of AVs in different parts of the U.S.

Obviously, both of these scenarios require an increase in funding for the NTSB, but it would be a worthwhile investment for the government to make if AV accident rates do in fact increase.

Other options were considered such as having the NTSB delegate responsibility to other organizations such as state agencies and the like. Unfortunately, this would probably require new legislation that is unlikely to be passed in an efficient manner. Furthermore, the NTSB already has a stellar reputation because of their response protocols and objective and thorough methods of analysis. We believe the NTSB as an organization is capable of dealing with the increased numbers of AV accidents; we think it is likely that giving power to state agencies to deal with investigations might diminish the unbiased investigative procedures because there might not be standardized processes that all state agencies must adhere to. Therefore, investigative power must come from the federal level, and the NTSB already has robust protocols to deal with accident investigations efficiently. The two methods we have suggested above should be able to reasonably address the issue of increasing AV accident rates.

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Appendix

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