August 22, 2022 Highway Investigation Report NTSB/HIR-22/05

Sport Utility Vehicle Centerline Crossover Collision with Pickup Truck on State Route 33

Avenal, California
January 1, 2021

Abstract: On January 1, 2021, about 8:00 p.m., a sport utility vehicle (SUV), occupied by only the driver, was traveling south on State Route 33 (SR-33) near Avenal, California. SR-33 is a two-lane roadway with one lane in each direction and a posted speed limit of 55 mph. The SUV driver had just left a New Year's Day gathering where he had consumed alcohol, and he was driving at a speed between 88 and 98 mph. The SUV partially departed from the paved roadway onto a dirt and gravel shoulder area to the right. The SUV driver then made a steering correction to the left, causing the vehicle to go out of control. The SUV crossed the highway centerline and intruded into the northbound lane directly in front of a northbound pickup truck, which was occupied by an adult driver and seven passengers, ranging in age from 6 to 15 years old, and was traveling at a speed between 64 and 70 mph. The SUV and pickup truck collided head-on. The pickup truck immediately caught on fire, and other vehicle operators on SR-33 who stopped at the crash scene had insufficient time to extricate any occupants before fire engulfed the truck. As a result of the crash, the SUV driver and all eight pickup truck occupants died. The safety issues addressed in this report include driver impairment and the need for technology to prevent alcohol-impaired driving crashes, the need for technology to prevent speeding-related crashes, and the need to implement a uniform standard for drug toxicology testing.

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Acronyms and Abbreviations

ACM	air bag control module
ACTS	Automotive Coalition for Traffic Safety, Inc.
ADAS	advanced driver assistance systems
BAC	blood alcohol concentration
CAL FIRE	California Department of Forestry and Fire Protection
Caltrans	California Department of Transportation
CDC	Centers for Disease Control and Prevention
CFR	*Code of Federal Regulations*
CHP	California Highway Patrol
CVT	Central Valley Toxicology, Inc.
DADSS	Driver Alcohol Detection System for Safety
DOT	US Department of Transportation
DUI	driving under the influence
DWI	driving while intoxicated
EDR	event data recorder
EMS	emergency medical services
Euro NCAP	European New Car Assessment Program
FAA	Federal Aviation Administration
FARS	Fatality Analysis Reporting System [NHTSA]
FMVSS	Federal Motor Vehicle Safety Standard
g/dL	grams per deciliter
GPS	global positioning system
IDTF	Impaired Driving Task Force [CHP]

ISA	intelligent speed adaptation
MADD	Mothers Against Drunk Driving
NCAP	New Car Assessment Program
ng/mL	nanograms per milliliter
NHTSA	National Highway Traffic Safety Administration
NSC	National Safety Council
NTSB	National Transportation Safety Board
PCM	powertrain control module
RFC	request for comments
RFI	request for information
RID	Remove Intoxicated Drivers
SR-33	State Route 33
SUV	sport utility vehicle
TASAS	Traffic Accident Surveillance and Analysis System [Caltrans]
THC	delta-9-tetrahydrocannabinol

Executive Summary

What Happened

On January 1, 2021, about 8:00 p.m., a sport utility vehicle (SUV), occupied by only the driver, was traveling south on State Route 33 (SR-33) near Avenal, California. SR-33 is a two-lane roadway with one lane in each direction and a posted speed limit of 55 mph. The SUV driver had just left a New Year's Day gathering where he had consumed alcohol, and he was driving at a speed between 88 and 98 mph. The SUV partially departed from the paved roadway onto a dirt and gravel shoulder area to the right. The SUV driver then made a steering correction to the left, causing the vehicle to go out of control. The SUV crossed the highway centerline and intruded into the northbound lane directly in front of a northbound pickup truck, which was occupied by an adult driver and seven passengers, ranging in age from 6 to 15 years old, and was traveling at a speed between 64 and 70 mph. The SUV and pickup truck collided head-on. The pickup truck immediately caught on fire, and other vehicle operators on SR 33 who stopped at the crash scene had insufficient time to extricate any occupants before fire engulfed the truck. As a result of the crash, the SUV driver and all eight pickup truck occupants died.

What We Found

The failure of the SUV driver to maintain control of his vehicle was due to a high level of alcohol impairment—his blood alcohol concentration was more than double California's per se legal limit of 0.08 grams per deciliter. Although the postcrash toxicology tests that were conducted at the request of the National Transportation Safety Board (NTSB) detected evidence of cannabis use, the NTSB was unable to determine whether the effects of cannabis use contributed to the driver's impairment.

Due to the high closing speed between the two vehicles and the suddenness of the lane incursion, the pickup truck driver had insufficient time to take evasive action to avoid the crash. Although the SUV driver and many of the pickup truck occupants were not appropriately restrained, it is unlikely that the crash was survivable, given the severity of the head-on crash, the significant vehicle intrusion, and the rapid spread of the postcrash fire.

Driving under the influence of alcohol remains a leading cause of injury-involved highway crashes. According to the National Highway Traffic Safety Administration (NHTSA), in 2020, roughly one in three traffic fatalities resulted from crashes involving alcohol-impaired drivers. Recent data show that impaired driving crashes are increasing. Because people who are impaired by alcohol often have compromised judgment and indulge in increased risk-taking, interventions are needed that do not require decision-making by impaired drivers. Vehicle-integrated passive alcohol detection technologies that prevent or limit impaired drivers from operating their vehicles have significant lifesaving potential; however, development of the technologies has been slow, and additional action is needed to accelerate progress in implementing these technologies.

The SUV driver's high rate of speed contributed to the crash severity and lack of survivability for occupants of both vehicles. Intelligent speed adaptation (ISA) is an effective vehicle technology to reduce speeding, and the severity of the Avenal crash might have been mitigated if the SUV had been equipped with a closed ISA system that limited its speed.

During the investigation, the NTSB learned that postmortem toxicology testing of the blood specimens conducted by the laboratory contracted by the Fresno County medical examiner did not include screening for cannabis. California has no uniform standard for drug toxicology testing, and information concerning the prevalence of impairing drug use by drivers would be improved if testing protocols were standardized. Moreover, without federal guidance or a regionally based standard for drug toxicology testing, policymakers have insufficient information with which to evaluate the effectiveness of countermeasures to address the problem of drugged driving.

We determined that the probable cause of this crash was the failure of the SUV driver to control his vehicle due to a high level of alcohol impairment. Contributing to the severity of the crash was the SUV driver's excessive speed.

What We Recommended

As a result of this investigation, we recommended that NHTSA require that all new vehicles be equipped with passive vehicle-integrated alcohol impairment detection systems, advanced driver monitoring systems, or a combination thereof; the systems must be capable of preventing or limiting vehicle operation if driver impairment by alcohol is detected. To ensure that the automotive industry is engaged in this important safety effort, we also recommended that the Alliance for Automotive Innovation inform its members (who manufacture close to 98 percent of the new cars and light trucks sold in the United States) about this crash and encourage them to accelerate development and prioritize deployment of advanced impaired driving prevention technology and to seek innovative ways to adapt existing technologies, such as driver monitoring systems, to combat alcohol-impaired driving. We also reiterated a recommendation to NHTSA to incentivize passenger vehicle manufacturers and consumers to adopt ISA systems by, for example, including ISA in the New Car Assessment Program (NCAP).

To address issues identified with drug toxicology testing in California, we recommended that the state enact legislation that requires forensic toxicology laboratories to follow the standards recommended by the National Safety Council's Alcohol, Drugs, and Impairment Division and to update testing protocols if additional federal guidance is provided. In conjunction with the recommendation to California, we also reiterated a recommendation to NHTSA to develop and disseminate to state officials a common standard of practice for drug toxicology testing.

1. Factual Information

1.1 Crash Narrative

On Friday, January 1, 2021, about 8:00 p.m., a 2013 Dodge Journey sport utility vehicle (SUV), driven by a 28-year-old male, was traveling south on State Route 33 (SR-33) near Avenal in Fresno County, California, when it crossed into the northbound lane and collided head-on with a northbound pickup truck. The 2007 Ford F-150 extended-cab pickup truck was being driven by a 34-year-old female and was transporting seven passengers, ranging in age from 6 to 15 years old.[1]

The SUV driver had just left a New Year's Day party and was en route to his residence in Avenal.[2] The pickup truck was returning to Coalinga, California, following a trip to Pismo Beach (see figure 1).

Figure 1. SR-33 crash location.

[1] Visit ntsb.gov to find additional information in the public docket for this National Transportation Safety Board (NTSB) investigation (case number HWY21FH003). Use the CAROL Query to search safety recommendations and investigations.

[2] The party was at a ranch property in unincorporated Fresno County about 1.2 miles north of the crash location.

The SUV driver traveled about 0.5 miles on unnamed dirt roads through an area of residential and farm properties before turning left onto southbound SR-33. After turning left, he accelerated to an estimated speed between 88 and 98 mph and, after less than 3,000 feet, partially departed from the travel lane.[3] (The speed limit for SR-33 was 55 mph.) The right-side tires of the SUV departed the paved roadway onto a dirt and gravel shoulder to the right of the southbound roadway. The driver made a steering correction to the left, which caused the SUV to begin a counterclockwise yaw. The SUV crossed the highway centerline into the northbound lane directly in front of the oncoming pickup truck. The pickup truck was traveling between 64 and 70 mph. The SUV and truck collided head-on in an offset orientation (see figures 2 and 3). Both vehicles rotated counterclockwise, and the SUV came to rest in the southbound lane facing northeast. The pickup truck came to rest adjacent to the northbound side of the roadway, facing northwest.

The truck immediately caught fire. Other vehicle operators on SR-33 who stopped to assist at the scene had insufficient time to extricate any occupants before the pickup truck was consumed by fire. As a result of the crash, the SUV driver and all eight pickup truck occupants died.

At the time of the crash, it was dark with clear weather and a dry road surface.

Figure 2. Northbound view of vehicles postcrash with SUV in southbound lane of SR-33 and truck off east road edge (Source: California Highway Patrol [CHP]).

[3] The speeds of the SUV and pickup truck were estimated based on a technical reconstruction analysis and a series of crash simulations. Refer to section 2.2.1, Crash Dynamics, of this report.

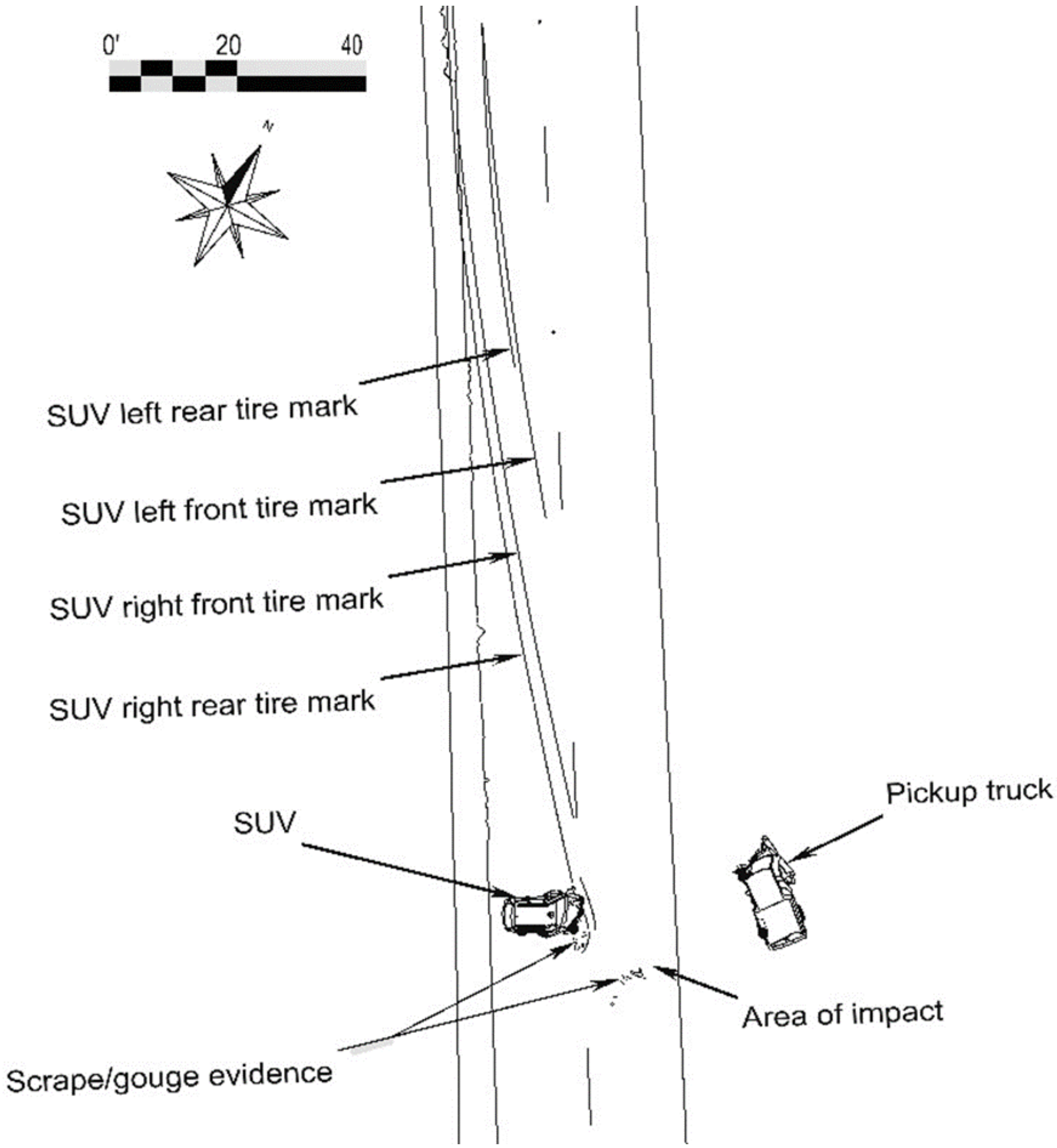

Figure 3. Crash scene diagram, showing at-rest positions of SUV and truck.

1.2 Injuries

The SUV driver was found lying across the SUV's center console with his upper body extending across the front passenger seat. The cause of his death was blunt-force trauma. The pickup truck driver and two children were found sitting in the three front seating positions. All died from blunt-force trauma. Four of the five children sitting in the rear were found in the right rear passenger seating area. The other child was found in the left rear passenger seating area. The children in the rear of the truck died from a combination of blunt-force trauma and thermal injuries.

1.3 Emergency Response

About 8:00 p.m., on January 1, 2021, the CHP Fresno Communications Center received a 911 call from a person reporting a two-vehicle crash with a truck engulfed in fire. The center immediately dispatched responders. One CHP unit and an engine unit from the California Department of Forestry and Fire Protection (CAL FIRE) arrived on scene at 8:09 p.m.

Fresno County emergency medical services (EMS), the Fresno County Sheriff's Office, the Avenal Police Department, and the California Department of Transportation (Caltrans) assisted CHP and CAL FIRE.

SR-33 was closed to all traffic for the duration of the emergency response and on-scene crash investigation. The roadway was reopened to traffic about 3:25 a.m.

1.4 Occupant Restraints

1.4.1 SUV

The SUV was equipped with a lap/shoulder belt for the driver's seating position. Postcrash examination of the restraint system showed no evidence that the driver was wearing the seat belt at the time of the crash.[4] The SUV was equipped with air bags for the driver and front passenger seating positions. All the air bags on the vehicle deployed during the collision sequence; these included the driver's steering-wheel-mounted air bag, the driver's knee bolster air bag, the driver's side seat air bag, the passenger's frontal and side seat air bag, and the left- and right-side curtain air bags.

1.4.2 Pickup Truck

The pickup truck was equipped with six seat belts. The driver and right-front passenger seats were equipped with lap/shoulder belts. The front middle seat was equipped with a lap-only belt. No booster seat was present for the 6-year-old seated in the front middle seat. The rear seat was equipped with three lap/shoulder belts (five children were seated in the rear seating area).[5] The truck was equipped with air

[4] The driver seat belt webbing was in a retracted position and locked in place by the retractor. No signs of loading or usage were noted in the various components of the restraint.

[5] *California Vehicle Code* section 27315 requires motor vehicle drivers and all passengers to be properly restrained by a safety belt. Section 27360 requires that children under 8 years of age sit in a child car seat or booster seat in the rear seating area of a vehicle. Both vehicle code sections are primary enforcement laws; this means that law enforcement officers may issue a citation anytime they observe an unbelted driver or passenger, or an improperly restrained child occupant.

bags for the driver and front passenger seating positions. Due to extensive thermal damage to the seat belts and air bags, it is unknown whether any of the seat belts were worn or whether the air bags deployed during the crash.

1.5 Vehicles

1.5.1 SUV

1.5.1.1 General

The 2013 Dodge Journey SUV had a front-engine/front-wheel-drive powertrain and was equipped with a 3.6-liter, gasoline-powered, six-cylinder engine. The vehicle had a curb weight of 3,801 pounds.[6]

1.5.1.2 Damage

The SUV sustained a major frontal impact, and the damage extended rearward more than 3.5 feet (see figure 4). The right front (passenger side) was pushed rearward, with the right front wheel and tire assembly twisted left, toward the engine compartment. The front bumper was bent inward and upward as well as displaced rearward with the hood and engine components. The leading edge of the roof was buckled, and both roof support structures were bent down and inward.

Figure 4. Left image depicts damage to front and right side of SUV. Right image is overhead view of 3D laser scan of SUV overlaid on exemplar vehicle.

1.5.1.3 Mechanical Systems

CHP investigators inspected the SUV and examined the steering, suspension, braking, and electrical systems, as well as the wheels and tires. The examination

[6] *Curb weight* is the weight of the vehicle including a full tank of fuel and all standard equipment. It does not include the weight of any passengers, cargo, or optional equipment.

revealed no evidence of preexisting conditions that would have contributed to the vehicle loss of control.

1.5.1.4 Inspection, Maintenance, and Safety Recalls

The SUV's registered owner (the driver's wife) described the vehicle as being well-maintained and in good condition. Routine brake inspections and oil changes had been completed and were up to date. A search of the safety recall database maintained by the National Highway Traffic Safety Administration (NHTSA) revealed no safety recalls or ongoing defect investigations relevant to the crash circumstances.[7]

1.5.1.5 Event Data Recording

The SUV was equipped with an air bag control module (ACM). The purpose of an ACM is to evaluate acceleration experienced by the vehicle in the event of a crash. Depending on the severity and direction of the acceleration, the ACM will determine when air bag deployment is warranted. The ACM also functions as an event data recorder (EDR) and can record operating data, crash severity data, and restraint device deployment data.[8] No precollision data were recorded associated with this crash due to a power interruption during the collision event and damage sustained by the ACM.

1.5.2 Pickup Truck

1.5.2.1 General

The truck was a 2007 Ford F-150 extended cab pickup truck, with four-wheel drive and a four-speed automatic transmission. Its curb weight was 5,554 pounds.

1.5.2.2 Damage

The truck sustained major frontal impact with the damage extending rearward more than 5 feet (see figure 5). The front bumper was bent and twisted rearward into the engine compartment area. The engine displacement caused the passenger compartment floor pan to deform upward. The left front tire and wheel was torn from

[7] A *safety recall* is an action taken by a manufacturer or a governmental agency due to an immediate safety hazard affecting the involved vehicle. A recall is initiated when a motor vehicle or item of motor vehicle equipment does not comply with a Federal Motor Vehicle Safety Standard (FMVSS) or when there is a safety-related defect with the vehicle or equipment.

[8] Title 49 *Code of Federal Regulations* (*CFR*) Part 563 establishes data recording requirements for EDRs installed in light vehicles manufactured on or after September 1, 2012. The EDR capability of the ACM installed in the SUV met the requirements of 49 *CFR* Part 563.

the truck during the crash sequence, and the left fender was peeled rearward. The right fender was buckled outward from the truck. The right front wheel was turned left with its bottom bent upward and inward beneath the vehicle.

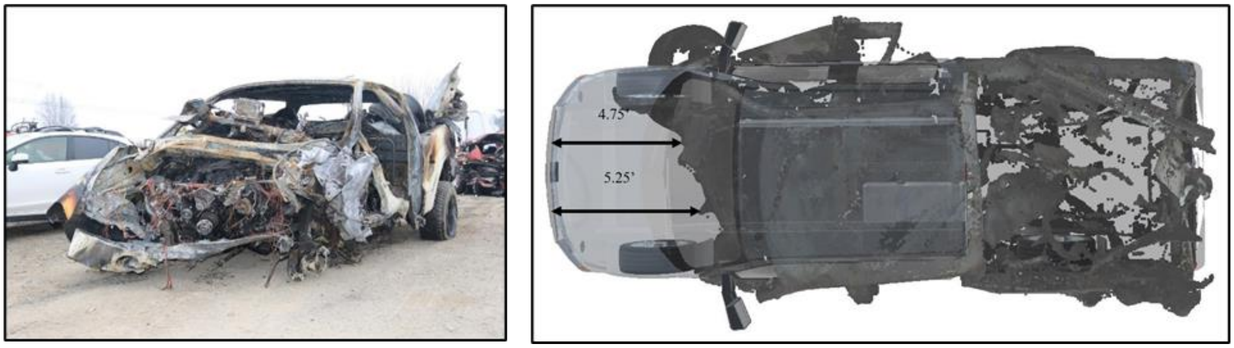

Figure 5. Left image depicts damage to front and left side of pickup truck. Right image is overhead view of 3D scan of truck overlaid on exemplar vehicle.

1.5.2.3 Mechanical Systems

Because of the extensive fire damage to the pickup truck, CHP investigators were unable to perform a complete functional check of the steering, suspension, braking, and electrical systems. A visual inspection of components did not reveal any preexisting defects.

The truck was examined to ascertain the ignition source of the postcrash fire. The entire undercarriage showed evidence of fire damage. The fuel intake was consumed by fire, and only remnants of the fuel tank remained. Most of the fire damage was near the engine and front passenger compartment; the directional fire pattern went from front to rear.[9] Other vehicle operators on SR-33 who stopped at the crash scene to assist reported seeing the fire start near the front of the truck and spread rearward. One witness reported that the fire originated from a severed line in the truck's engine compartment. Another said the fire originated near the bottom of the truck's firewall.

[9] The truck was equipped with an inertial fuel pump shut-off switch that stops the electric fuel pump from sending fuel to the engine when the vehicle sustains a substantial jolt. The switch is located on the front passenger's footwell, behind the kick panel access cover, to the left of the fuse box. Due to the extensive fire damage, the functionality of the switch could not be determined. Because the battery (mounted on the passenger side of the engine compartment) was damaged during the crash sequence, no power was available for the electric fuel pump to continue operating after the impact with the SUV.

1.5.2.4 Inspection, Maintenance, and Safety Recalls

The pickup truck's registered owner (the husband of the driver) described the vehicle as being well-maintained and in good condition. The owner reported that, 3–4 months before the crash, the truck was brought to an automobile repair facility for installation of new tires, vehicle alignment, and tire balancing. The truck's brakes were also inspected and found to be in good condition. A search of the safety recall database maintained by NHTSA revealed no recalls or ongoing defect investigations related to the circumstances of the crash.

1.5.2.5 Event Data Recording

The pickup truck was equipped with a powertrain control module (PCM) that controls most engine and drivetrain functions. The truck was also equipped with an ACM. The PCM and ACM monitor information generated by various vehicle sensors using the truck's communication network. In the event of a crash of sufficient severity that a deployment of a restraint device is necessary, the ACM sends a signal to the PCM via the vehicle's communication network. Upon receipt of this signal, the PCM locks pertinent precrash vehicle data (vehicle speed, accelerator pedal position, brake switch status, etc.).[10] During the crash, the truck sustained extensive thermal damage to the engine and occupant compartments—this resulted in the PCM being destroyed and the ACM having major damage. As a result, no electronic data were available.

1.6 Driver Factors

1.6.1 SUV Driver

1.6.1.1 Licensing and Experience

The SUV driver, a 28-year-old male, was unlicensed with no record of ever having possessed a driver's license. The SUV driver had a March 7, 2018, traffic citation on his record for traveling at an unsafe speed for conditions and for driving without a license. He failed to appear in court for these violations.[11] The driver had no

[10] The recording capability of the PCM and ACM met the requirements for an EDR as outlined in 49 *CFR* Part 563.

[11] When a person does not appear in court for a traffic ticket, it is called a "failure to appear." In California, if a person fails to appear, the court can assign a civil assessment to be added to any fine amount. The court could also find a person who fails to appear guilty in absentia and refer the case for fine collection. Or the court could issue an arrest warrant for a person who fails to appear.

crashes or other driving-related convictions on his record.[12] His wife said that he was familiar with the SR-33 highway environment and was aware of the 55-mph speed limit because the roadway was used daily as his route to work.

The wife of the SUV driver said that her husband had experience driving trucks and tractors at agricultural work locations. The SUV was registered to the driver's wife. The wife said that her husband was not allowed to drive the SUV because it was the family's only vehicle, it was not registered to him, he was not on the SUV's insurance policy, and he did not have a driver's license. The wife said that she regularly drove her husband to and from work. She said that, occasionally, the SUV driver would insist on taking the vehicle and driving it to perform local errands. On the day of the crash, the wife said her husband took the SUV's keys and operated the vehicle without her permission. The driver's wife did not attend the New Year's Day party with him.

1.6.1.2 Health

According to his wife, the SUV driver was not under the care of a primary care physician and was not taking any prescription medications. She said that he had some vision problems but reported that he had not been evaluated to determine whether he needed eyeglasses. Regarding his mental health, his wife said that he had a lot of stress in his life and was concerned about finances. She reported that he did not sleep well at night because of frequent nightmares related to previous trauma. She did not notice that he had any problems sleeping on the night before the crash.

1.6.1.3 Alcohol and Other Drug Use

According to his wife, the SUV driver was a regular, "daily" user of cannabis, and he preferred smoking cannabis to drinking alcohol.[13] She said that he would typically smoke cannabis 2–3 times a day, usually in the afternoon when he got home from work, about 4:00 p.m., and then again later in the early evening. She said that the SUV driver was trying to cut back on his cannabis use and was down to using about 3.5 grams (1/8 ounce) per week. Regarding alcohol use, his wife said that he would normally only drink at social gatherings and estimated that he drank once or twice a month.

[12] The SUV driver had other interactions with the judicial system but none that were related to traffic.

[13] The terms *cannabis* and *marijuana* are used interchangeably throughout this report. Cannabis (marijuana), which can also be called "weed," "pot," or "dope," comes from the flowers and leaves of the cannabis plant. It contains mind-altering (psychoactive) compounds, such as delta-9-carboxy-tetrahydrocannabinol (THC).

1.6.1.4 Toxicology Results

Forensic toxicology testing conducted by Central Valley Toxicology, Inc., (CVT) for the Fresno County medical examiner, as part of the SUV driver's autopsy, found a blood alcohol concentration (BAC) of 0.21 grams per deciliter (g/dL).[14] California's per se alcohol BAC limit is 0.08 g/dL.[15]

The CVT testing did not identify the presence of any other commonly abused drugs; however, the lab did not screen for the presence of cannabis.[16]

The NTSB arranged for a separate sample of the SUV driver's blood to be sent to the Federal Aviation Administration (FAA) Forensic Sciences Laboratory. Toxicology testing detected ethanol at 0.188 g/dL and delta-9-tetrahydrocannabinol (THC), the primary psychoactive ingredient in cannabis, at 7.2 nanograms per milliliter (ng/mL).[17] The testing also detected 11-hydroxy-THC (a psychoactive metabolite of THC) at 3.4 ng/mL, and carboxy-THC (an inactive metabolite of THC) at 26.1 ng/mL.

1.6.1.5 Precrash Activities

The NTSB determined the SUV driver's precrash activities based on cell phone data, information obtained during witness interviews, and CHP dispatch records. Table 1 presents a timeline of the SUV driver's activities on the day of the crash and for the previous 2 days.

[14] BAC is measured as a mass of alcohol per volume of blood. In the United States, the standard measurement is represented as grams per deciliter (g/dL).

[15] *Per se BAC laws* establish the BAC level at which it is illegal per se (in itself) for a driver to operate a vehicle, regardless of the driver's apparent condition or actions.

[16] The blood was tested for the presence of cocaine, opiates, amphetamines, barbiturates, benzodiazepines, methadone, fentanyl, tricyclic antidepressants, carisoprodol, and PCP.

[17] Ethanol is commonly found in beer, wine, and liquor, and it acts as a central nervous system depressant. The terms *ethanol* and *alcohol* are used interchangeably throughout this report.

Table 1. Precrash activities of SUV driver, December 30, 2020–January 1, 2021.

Time	Activity	Information Source
Wednesday, December 30, 2020		
4:00 a.m.	Awakes	NTSB interview with wife
4:30 a.m.	Wife drives him to work	NTSB interview with wife
5:00 a.m. – 4:00 p.m.	Works at pistachio tree farm near Sutter Avenue and SR-33	NTSB interview with wife
4:00 p.m.	Wife picks him up at work and returns to home in Avenal	NTSB interview with wife
9:00 p.m.	Goes to bed	NTSB interview with wife
Thursday, December 31, 2020		
4:00 a.m.	Awakes	NTSB interview with wife
4:30 a.m.	Wife drives him to work	NTSB interview with wife
5:00 a.m. – 8:00 a.m.	Works at pistachio tree farm. Work ended early due to inclement weather (rain)	NTSB interview with wife
8:00 a.m.	Wife picks him up at work and returns to home in Avenal	NTSB interview with wife
11:02 a.m.	Interacts with phone	Cell phone data
Friday, January 1, 2021		
1:15 a.m.	Interacts with phone	Cell phone data
1:30 a.m.	Goes to bed following New Year's Eve activities	NTSB interview with wife
8:00 a.m. – 9:00 a.m.	Awakes	NTSB interview with wife
3:00 p.m.	Departs home in SUV and drives himself to ranch property in Fresno County (about 1.2 miles from the crash site)	NTSB interview with wife
3:17 p.m.	Interacts with phone while at ranch property	Cell phone data
3:20 p.m. – 7:55 p.m.	Attends party with family and friends at ranch. Consumes food and beer at party	CHP interview with family and friends attending ranch party
7:55 p.m.	Departs ranch to drive home	CHP interview with family and friends attending ranch party
8:00 p.m.	Crash	Dispatch records

On January 1, 2021, the SUV driver attended a party at a ranch property in an unincorporated area of Fresno County from about 3:20 p.m. to about 7:55 p.m. Family members and friends attending the party reported seeing the SUV driver consuming beer, but nobody acknowledged seeing the driver in an obviously intoxicated state.[18] Party participants served themselves alcoholic beverages. No one reported seeing the SUV driver smoking cannabis during the gathering.

[18] The CHP observed the brother of the SUV driver when he arrived at the crash site. The brother displayed objective signs of intoxication, including the odor of an alcoholic beverage, red and watery eyes, and slightly slurred speech. Other family members, including the SUV driver's father, also arrived at the crash site and displayed similar signs of alcohol intoxication.

The SUV driver crashed within minutes of leaving the party, after traveling about 1.2 miles from the ranch property. Figure 6 shows the likely route of travel from the ranch property to the crash location.

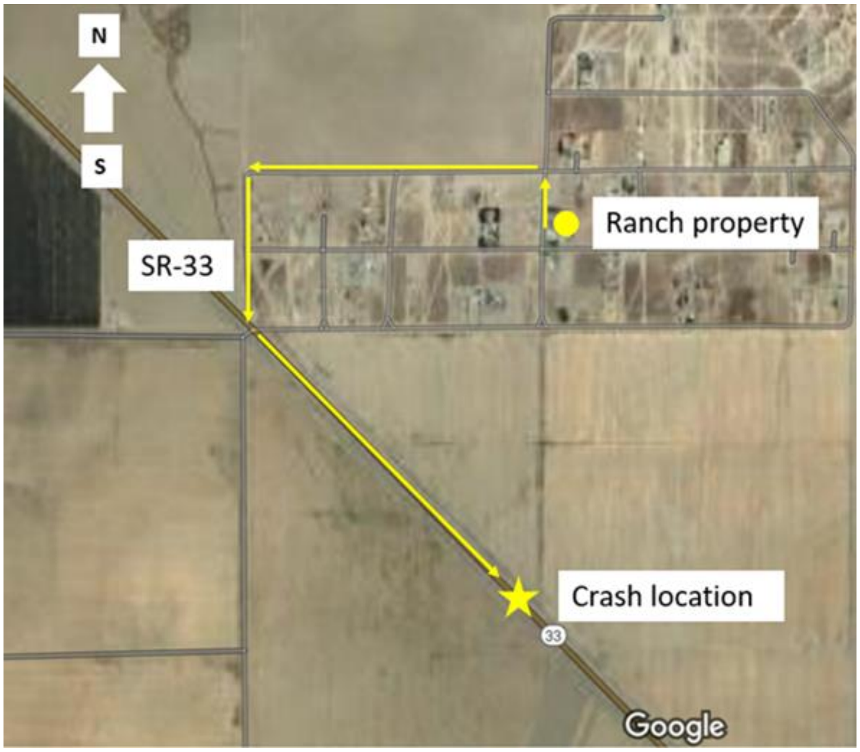

Figure 6. SUV driver's route of travel from ranch property to crash location. (Source: Google Earth, 2021)

1.6.1.6 Cell Phone Use

A review of data extracted from the SUV driver's cell phone showed that the device was not in use during the driver's trip from the ranch property to the crash location.

1.6.2 Pickup Truck Driver

1.6.2.1 Licensing and Experience

The pickup truck driver, a 34-year-old female, held a California class C driver's license allowing passenger vehicle operation. Her driving record showed no previous crashes and two traffic violations. One traffic citation was issued in April 2019 for having no proof of car insurance. In June 2019, the driver was cited again for having no insurance and for a child passenger restraint violation.[19] The pickup truck driver was wearing eyeglasses at the time of the crash in accordance with a restriction on her driver's license requiring her to wear corrective lenses while driving. The driver was the primary operator of the pickup truck and was familiar with her route of travel on SR-33.

1.6.2.2 Health

The pickup truck driver's family reported that she was in good health. They said that she had no known health conditions other than mild high blood pressure, which was under control due to recent weight loss. Her husband said that he did not believe that she was taking any prescription medications.

1.6.2.3 Alcohol and Other Drug Use

According to her husband, the pickup truck driver used cannabis occasionally; usually on weekends when she did not have physical custody of her children. Her husband added that she would never smoke cannabis in front of the children. Her family said that she would usually purchase cannabis from a licensed dispensary in Coalinga but did not know when she had last used cannabis. Her family said that she did not consume alcohol on a regular basis; she would occasionally drink alcohol at social gatherings but never to excess.

1.6.2.4 Toxicology Results

Forensic toxicology testing of a blood specimen conducted by CVT for the Fresno County medical examiner as part of the pickup truck driver's autopsy found a BAC of 0.05 g/dL. The CVT testing did not identify the presence of any other commonly abused drugs; the testing did not screen for the presence of cannabis.

The NTSB arranged for a separate sample of the driver's blood to be sent to the FAA Forensic Sciences Laboratory.[20] This additional toxicology testing did not

[19] The specific details of the child passenger restraint violation are unknown. The driver was cited for violation of *California Vehicle Code* section 27360.5, which requires that children who are 8 years or older but under age 16 be properly secured in a child restraint or a vehicle safety belt that fits. A driver can also be cited for this section if the child is wearing a seat belt inappropriately, such as wearing a seat belt that is placed under the arm or behind the back.

[20] The samples tested by CVT and the FAA were collected on different dates and at different times.

detect ethanol.[21] It did detect THC at 2.4 ng/mL and carboxy-THC at 14 ng/mL. Testing for 11-hydroxy-THC was inconclusive.

1.6.2.5 Precrash Activities

The NTSB determined the pickup truck driver's precrash activities based on cell phone data, information obtained during family interviews, and CHP dispatch records. Table 2 presents the timeline of the pickup truck driver's activities on the day of the crash and the 2 preceding days.

Table 2. Precrash activities of pickup truck driver, December 30, 2020–January 1, 2021.

Time	Activity	Information Source
Wednesday, December 30, 2020		
5:30 a.m.	Awakes	NTSB interview with family
7:00 a.m. – 3:30 p.m.	Works at Coalinga State Hospital	NTSB interview with family
9:00 p.m. – 10:00 p.m.	Goes to bed	NTSB interview with family
Thursday, December 31, 2020		
5:30 a.m.	Awakes	NTSB interview with family
7:00 a.m. – 3:30 p.m.	Works at Coalinga State Hospital	NTSB interview with family
5:00 p.m. – 9:00 p.m.	Spends New Year's Eve at parent's house in Coalinga	NTSB interview with family
9:00 p.m.	Returns home	NTSB interview with family
Friday, January 1, 2021		
12:45 a.m. – 1:14 a.m.	Interacts with phone (game application)	Cell phone data
8:00 a.m. – 9:00 a.m.	Awakes	NTSB interview with family
9:00 a.m.	Departs on trip to beach	NTSB interview with family
11:00 a.m. – 5:00 p.m.	Spends day with family in Pismo Beach area	NTSB interview with family and cell phone data
5:00 p.m. – 6:00 p.m.	Has dinner at restaurant in Pismo Beach	Cell phone location data
6:00 p.m. – 6:30 p.m.	Departs Pismo Beach to drive home	CHP interview with family and cell phone data
7:25 p.m.	Interacts with phone while driving (incoming phone call answered – 11 secs.)	Cell phone data
8:00 p.m.	Crash	Dispatch records

1.6.2.6 Cell Phone Data

A review of data extracted from the pickup truck driver's cell phone showed that she did not use the device during the 30 minutes before the crash.

[21] In this case, ethanol levels varied from the specimen tested by CVT compared to the separate specimen tested by the FAA Forensic Sciences Laboratory. Ethanol may be produced in body fluids and tissues after death by microbial activity. For additional information on the likely reason for the different test results, see section 2.3.2 in the Analysis portion of this report.

1.7 Highway Factors

1.7.1 Description and Characteristics

The crash occurred in Fresno County on SR-33, about 2 miles north of the city of Avenal. SR-33 is a designated north–south highway; it is orientated northwest–southeast at the crash location.

The crash occurred along a straight segment of roadway about 1 mile north of the Kings/Fresno County line (see figure 7). SR-33 is an asphalt-paved, two-lane roadway with one lane in each direction of travel (northbound and southbound). The roadway is in good condition with a cross section measuring 28 feet wide. The travel lanes are about 12 feet wide with approximately 2-foot-wide paved shoulders. The lanes are divided by 6-inch-wide yellow dashed centerline pavement stripes. The shoulders are delineated from the travel lanes by 6-inch-wide white solid pavement stripes.[22] Unimproved dirt and gravel shoulders border both edges of the paved highway.[23]

Figure 7. Northbound view of SR-33 at crash location.

[22] According to the California Department of Transportation, no longitudinal rumble strips were milled into the shoulder due to the narrow shoulder width at the crash location and this area's limited history of run-off-the-road crashes.

[23] There is an approximately 1-inch-high drop-off from the edge of the paved asphalt surface to the unimproved shoulder.

1.7.2 Traffic Volume, Speed, and Crash History

In 2017, the average daily traffic count for this area of SR-33 was 3,100 vehicles per day. The posted speed limit is 55 mph. A speed limit sign is located about 1 mile south of the crash location near the Kings County/Fresno County line. The sign faces northbound SR-33 traffic.

The NTSB reviewed California Department of Transportation (Caltrans) Traffic Accident Surveillance and Analysis System (TASAS) data for the 3-mile-long segment of SR-33 centered on the crash site (1.5 miles north and 1.5 miles south of the crash site) from 2015 to 2020. Thirteen crashes occurred on this segment during this period: 8 were property-damage-only crashes, 4 were injury crashes, and 1 was a run-off-the-road fatal crash. During this same 5-year period, there were no centerline crossover, head-on collisions (such as the subject crash).

1.8 Weather and Illumination

On January 1, 2021, at 7:53 p.m., the weather at Avenal was partly cloudy, the temperature was 47°F, and the wind was from the northeast at 5 mph. The roadway was dry, and there was no precipitation at or near the time of the crash. It was dark, and no ambient lighting was present at the crash location. Sunset occurred at 4:57 p.m. Moonrise occurred at 7:40 p.m. and provided limited additional lighting due to the partly cloudy condition and the moon’s position low on the horizon.

2. Analysis

2.1 Introduction

The Avenal crash involved a 2013 Dodge Journey SUV and a 2007 Ford F-150 extended-cab pickup truck. The 28-year-old SUV driver, traveling south on SR-33, partially departed the travel lane to the right. The driver then made a steering correction to the left, causing the vehicle to enter an out-of-control counterclockwise yaw. The SUV crossed the highway centerline into the northbound lane directly in front of the oncoming pickup truck. As a result of the crash, the SUV driver and all eight occupants of the pickup truck died.

This analysis discusses the dynamics, severity, and survivability of the crash (section 2.2) and evaluates the following safety issues:

- Driver impairment and the need for technology to prevent alcohol-impaired driving crashes (sections 2.3 and 2.4)
- Need for technology to prevent speeding-related crashes (section 2.5)
- Need to implement a uniform standard for drug toxicology testing (section 2.6)

Based on a comprehensive review of the circumstances that led to the Avenal crash, the NTSB determined that the following factors did not contribute to the cause of the collision:

- **Familiarity with vehicles and roadway:** Both drivers were familiar with their vehicles and the SR-33 operating environment.
- **Medical conditions or fatigue:** Neither the SUV driver nor the pickup truck driver was known or found to have had any significant medical conditions. Both drivers had 6.5–7.5 hours of sleep opportunity the night before the crash and at least 7 hours of sleep opportunity in each of the preceding nights.
- **Cell phone use:** According to records obtained from cell phone providers and analysis of data extracted from both drivers' phones, neither driver was interacting with their cell phone at the time of the crash.
- **Vehicle mechanical condition:** The NTSB found no evidence of mechanical problems with the SUV or the pickup truck that would have contributed to the crash.

- **Highway condition:** An examination of the highway environment revealed no safety deficiencies that would have contributed to the crash.
- **Weather:** Although the weather was cloudy, there was no precipitation at or near the time of the crash, and the roadway was dry.

The NTSB, therefore, concludes that none of the following were factors in the crash: (1) drivers' familiarity with their vehicles or the roadway, (2) medical conditions or fatigue, (3) cell phone use, (4) mechanical condition of either vehicle, (5) highway condition, or (6) weather.

Immediately following the crash, bystanders notified the CHP Fresno Communications Center of the collision, and an emergency response was coordinated. Despite the rural location of the crash, CHP and fire department resources arrived at the collision site within 9 minutes of being dispatched. Because the postcrash fire started immediately after the impact, the pickup truck was fully engulfed upon fire department arrival, making extrication of occupants impossible until the fire was extinguished. Moreover, the SUV driver sustained fatal blunt-force trauma injuries during the crash. The multi-agency response consisted of local and state emergency service agencies, which included resources from the CHP, CAL FIRE, Fresno County EMS, the Fresno County Sheriff's Office, the Avenal Police Department, and Caltrans. The NTSB concludes that the emergency response efforts were timely and adequate.

2.2 Crash Discussion

2.2.1 Crash Dynamics

Shortly before the crash, the SUV driver departed a ranch property where he was attending a party. After traveling about 0.5 miles on unnamed dirt roads through an area of residential and farm properties, he turned left onto southbound SR-33. The SUV had traveled less than 3,000 feet on SR-33, during which it accelerated to a speed between 88 and 98 mph, when the vehicle's tires departed the paved roadway onto the dirt and gravel shoulder to the right of the roadway.[24] The driver then made a steering correction to the left, causing the SUV to enter an out-of-control counterclockwise yaw. The SUV continued in a counterclockwise yaw across the southbound lane and crossed over the centerline into the northbound lane. As the SUV crossed into the northbound lane, it collided head-on with a northbound Ford pickup truck. The pickup truck was traveling between 64 and 70 mph within the northbound lane. Both vehicles rotated counterclockwise, and the SUV came to rest

[24] The speeds of the SUV and pickup truck were estimated based on a technical reconstruction analysis and a series of crash simulations. For more information, refer to the Vehicle Performance Study in the public docket for this investigation.

in the southbound lane facing northeast. The pickup truck came to rest adjacent to the northbound side of the roadway, facing northwest. Figure 8 depicts the crash dynamics and final rest positions of both vehicles.

Based on a review of the crash dynamics, the NTSB concludes that the SUV driver's failure to keep his vehicle on the paved portion of the highway, in combination with his excessive speed, resulted in a loss of vehicle control when he oversteered while attempting to reenter the roadway.

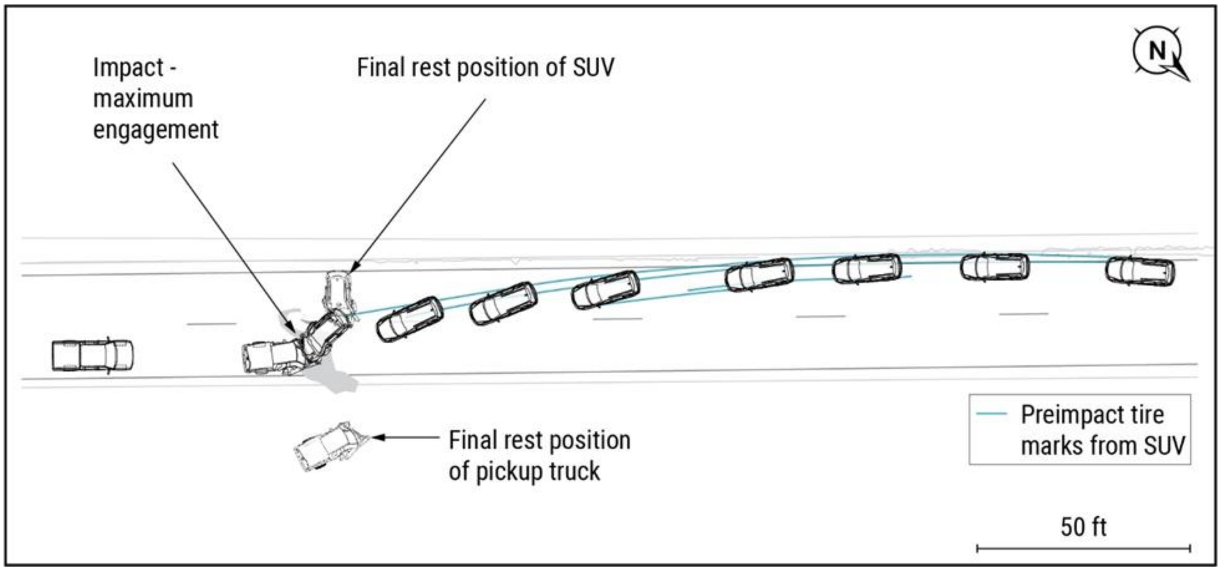

Figure 8. Precrash motion of SUV leading to impact and final areas of rest for both vehicles.

An analysis of tire marks on the paved roadway showed that the SUV reentered the southbound travel lane about 102 feet before striking the truck. Based on the SUV's high speed, it took less than 0.8 seconds for the SUV to reach the point of impact while traveling out of control toward the approaching truck. This would not have provided enough time for the pickup truck driver to perceive the threat and react to avoid the SUV (Green 2000). Therefore, the NTSB concludes that, due to the high speed of the SUV and the short distance from where the SUV reentered the roadway to the impact location, the pickup truck driver had insufficient time to take evasive action to avoid the crash.

2.2.2 Crash Severity and Survivability

Before the crash, the SUV and pickup truck had a closing speed of over 150 mph. The offset head-on collision resulted in significant intrusion to both vehicles as the SUV struck and intruded into the front of the pickup truck. Three-dimensional survey data of both vehicles were analyzed and figure 9 was created, depicting the interaction of the vehicles at maximum engagement during the crash sequence. The

NTSB conducted a series of crash simulations to examine the severity of the crash. The simulations showed that the SUV experienced a speed change (delta-V) of over 90 mph, and the pickup truck underwent a delta-V of at least 56 mph during the collision.[25] These speed changes occurred within a very short period, causing catastrophic intrusion into the passenger compartment and reducing the likelihood of crash survivability.

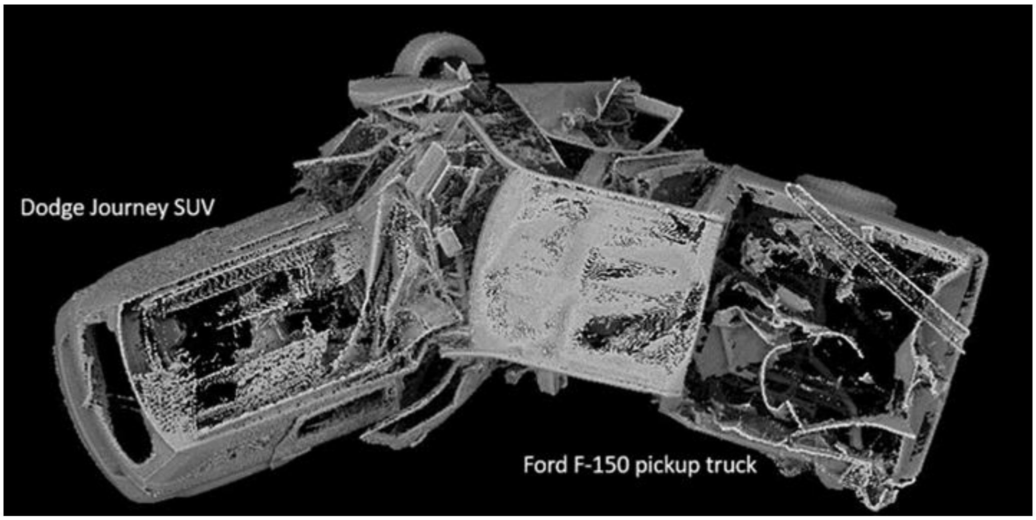

Figure 9. Approximate orientation of vehicles at maximum engagement during crash.

As a result of the crash, a fire started in the pickup truck's engine compartment and spread rapidly throughout the vehicle. Other vehicle operators on SR-33 who came upon the crash shortly afterward reported that the fire quickly engulfed the pickup truck, and they did not have time to extricate any truck occupants. Based on the postcrash positions of the SUV driver and children in the pickup truck, that only six seat belts were available for the eight occupants of the truck, and that no booster seat was provided for the 6-year-old, the NTSB determined that some of the vehicle occupants were not appropriately restrained. Given the severity of the crash and the rapid spread of the fire, however, it is unlikely that any of the occupants of the two vehicles could have survived this crash even if they had been appropriately restrained. Therefore, the NTSB concludes that, although the driver of the SUV and some occupants of the pickup truck were not appropriately restrained, it is unlikely that the crash was survivable, given the severity of the head-on collision, the significant vehicle intrusion, and the rapid spread of the postcrash fire in the pickup truck.

[25] *Delta-V* is defined as the change in velocity over the duration of the crash event. Delta-V is a measure of the severity of a traffic collision and can be used as a predictor of occupant injury in crashes.

2.3 Driver Impairment

Postmortem toxicology testing detected both ethanol and delta-9-THC in blood samples from both drivers. This section will examine possible impairment from alcohol and cannabis use.

2.3.1 SUV Driver

2.3.1.1 Alcohol Impairment

The SUV driver consumed alcohol at a New Year's Day gathering during a 4-hour period before the crash. The driver crashed within minutes of departing the event, and postmortem toxicology testing indicated BACs of 0.188 g/dL and 0.21 g/dL in separate blood specimens tested at two laboratories.[26] The current legal definition of per se alcohol impairment in 49 of 50 states (including California) is a BAC of 0.08 g/dL or higher.[27] Although this is the per se limit set by state law, impairment begins at lower concentrations; even small amounts of alcohol affect the brain.[28]

After consuming alcohol, the human body undergoes multiple changes that can affect perception and performance. The effects of alcohol include psychomotor impairment, decreased inhibition, diminished alertness, confusion, problems with concentration, reduced visual focus, and slurred speech (Teutsch, Geller, and Negussie 2018). Driving requires several complex skills. A driver must maintain the correct speed and keep the vehicle in the travel lane while observing and processing the surrounding area for safety information (such as traffic signage, other vehicles, and pedestrians). Alcohol affects the capacity to drive safely by impairing information processing and reaction time and compromising judgment and coordination (Centers for Disease Control and Prevention [CDC] 2021).

A variety of factors can influence the relationship between alcohol consumption and the resulting BAC; in general, alcohol's effects are dose-dependent, meaning that its impact increases or becomes more severe as more alcohol is

[26] BAC test results can vary when specimens are collected at different times and at different collection sites. Both toxicology results point to a level of alcohol intoxication that far exceeded the legal limit for alcohol in drivers in California (0.08 g/dL).

[27] On December 30, 2018, Utah became the first state to lower the per se legal BAC limit from 0.08 g/dL to 0.05 g/dL.

[28] In its 2013 report *Reaching Zero: Actions to Eliminate Alcohol-Impaired Driving* (NTSB 2013), the NTSB concluded that changing legal per se BAC limits from 0.08 to 0.05 g/dL or lower would lead to meaningful reductions in crashes, injuries, and fatalities caused by alcohol-impaired driving and called for the states to establish a per se BAC limit of 0.05 g/dL or lower for all drivers not already required to adhere to lower BAC limits (Safety Recommendation H-13-5).

consumed.[29] As shown in table 3, increases in BAC are accompanied by both physiological effects and predictable effects on an individual's driving capability, including reduced ability to control speed, keep lane position, and maintain vehicle control.[30]

Table 3. BAC levels, physiological effects, and effects on driving.

BAC (g/dL)	Typical Physiological Effects	Predictable Effects on Driving
0.02	Some loss of judgment, slight increase in body warmth, altered mood	Decline in visual functions (rapid tracking of a moving target), decline in ability to perform two tasks at the same time (divided attention)
0.05	Exaggerated behavior, may have loss of small-muscle control (such as trouble focusing eyes), impaired judgment, lowered alertness, release of inhibition	Reduced coordination, diminished ability to track moving objects, difficulty steering, reduced response to emergency driving situations
0.08	Muscle coordination becomes poor (affecting balance, speech, vision, reaction time, and hearing); harder to detect danger; judgment, self-control, reasoning, and memory are impaired	Diminished concentration, short-term memory loss, less speed control, reduced information processing capability (such as signal detection and visual search), impaired perception
0.10	Clear deterioration of reaction time and control, slurred speech, poor coordination, and slowed thinking	Reduced ability to maintain lane position and to brake appropriately
0.15	Far less muscle control than normal, vomiting may occur (unless this level is reached slowly or a person has developed a tolerance for alcohol), major loss of balance	Substantial impairment to maintaining vehicle control, to focusing attention on driving task, and to processing necessary visual and auditory information

The SUV driver's high speed (between 88 and 98 mph), difficulty steering and maintaining lane position, and loss of ability to maintain vehicle control (particularly, entering an out-of-control yaw and crossing into the opposing lane of travel) were consistent with the negative effects on driving associated with a high level of alcohol intoxication (Hingson and Winter 2003). Therefore, the NTSB concludes that the SUV driver's high level of alcohol intoxication contributed to his excessive speed and loss of vehicle control, resulting in the centerline crossover and head-on collision.

[29] The factors that may affect the relationship between alcohol consumption and BAC include the individual's sex and weight, the concentration of alcohol in the consumed beverage, and the rate at which the beverage is consumed.

[30] Table 3 was adapted from NHTSA drunk driving information (accessed June 15, 2022).

2.3.1.2 Cannabis Impairment

Many studies have documented that cannabis affects psychomotor skills and cognitive functions critical to driving, including vigilance, time and distance perception, reaction time, divided attention, lane tracking, and coordination (Capler and others 2017; NHTSA 2017; Strand, Gjerde, and Mørland 2016).

According to his wife, the SUV driver was a regular, "daily" user of cannabis, and he preferred smoking cannabis to drinking alcohol.[31] She said he would usually smoke cannabis two to three times a day, typically in the afternoon when he got home from work (about 4:00 p.m.) and again later in the early evening. However, no family members or friends reported seeing the SUV driver smoking cannabis on the day of the crash.

Postmortem toxicology testing of the SUV driver detected THC at 7.2 ng/mL. However, THC levels alone may not be sufficient to determine whether a driver is impaired by cannabis because THC levels do not correlate well with impairment (NHTSA 2017). Concentrations of THC in a person's body vary, depending on the potency of the cannabis and the way the drug is used, as well as on dosing patterns; however, peak plasma concentrations of 100–200 ng/mL are routinely encountered shortly after a person smokes cannabis (NHTSA 2014).[32] Plasma concentrations of THC decline rapidly and are often less than 5 ng/mL within 3 hours of ingestion in occasional users (NHTSA 2014). Significant performance impairments are usually observed up to 3–4 hours following cannabis use, and residual effects have been reported up to 24 hours later (NHTSA 2014). THC is stored in fatty tissues and can be released back into the blood long after consumption and even after death (Bergamaschi and others 2013, Holland and others 2011).

The NTSB was unable to determine whether the THC detected in the SUV driver's postmortem blood sample resulted from recent cannabis use or whether it may have been associated with other factors, such as his habitual cannabis use or postmortem redistribution. The NTSB concludes that, although toxicology testing detected evidence of cannabis use by the SUV driver, the NTSB was unable to determine whether the effects of cannabis use contributed to the driver's impairment.

[31] In California, cannabis has been legal for medical use since 1996 and for recreational use since late 2016.

[32] *Plasma* is the liquid component of blood that consists of water, proteins, and other constituents but not blood cells. *Plasma concentration* refers to the concentration of an agent (such as THC) in the plasma.

2.3.2 Pickup Truck Driver

In examining the pickup truck driver's possible impairment by alcohol or other drugs at the time of the crash, the NTSB evaluated the toxicology testing conducted by CVT for the Fresno County medical examiner and by the FAA Forensic Sciences Laboratory.[33] Toxicology testing identified 0.05 g/dL of ethanol in one blood specimen from the pickup truck driver but none in a separate blood sample tested by the FAA lab. After ingestion, ethanol is rapidly distributed throughout the body tissues at very similar levels. The absence of ethanol in one specimen suggests that the ethanol identified in the blood sample tested by Fresno County was most likely the result of postmortem production rather than ingestion.

Postcrash testing also demonstrated evidence of cannabis use; however, the levels of THC and its metabolites were very low. Because only limited information is available regarding the pickup truck driver's activities during her daytrip to Pismo Beach, it is unknown when she had last used cannabis. As described in section 2.2.1, the pickup truck was entirely within the northbound travel lane when the SUV crossed over the centerline, and the pickup truck driver had less than 1 second to take evasive action to avoid the collision. Therefore, the NTSB concludes that, although cannabis was detected in the pickup truck driver's blood, given the limited time the pickup truck driver had to respond to the head-on approach of the SUV, the effects of the pickup driver's cannabis use did not contribute to the crash.

2.4 Technology to Prevent Alcohol-Impaired Driving Crashes

The NTSB has long been concerned about alcohol-impaired driving, which accounts for nearly one in three US highway fatalities. Since 1968, the NTSB has issued nearly 150 safety recommendations addressing impaired driving, and the issue area "Prevent Alcohol- and Other Drug-Impaired Driving" is on the NTSB's Most Wanted List of Transportation Safety Improvements.[34] Yet, despite all efforts to date, tragedies such as the Avenal crash—involving a highly impaired driver and resulting in multiple fatalities—occur all too frequently today. This section of the report will review the scope of the alcohol-impaired driving problem, the efforts to reduce alcohol-impaired driving, and the critical need to develop safe vehicle technologies that will prevent or limit vehicle operation if driver impairment is detected.

[33] The blood sample analyzed by the FAA laboratory was collected at a different date and time than the sample analyzed for Fresno County.

[34] Refer to Prevent Alcohol- and Other Drug-Impaired Driving (ntsb.gov), accessed June 15, 2022.

2.4.1 Scope of the Alcohol-Impaired Driving Problem

2.4.1.1 Alcohol Involvement in Fatal Crashes

Alcohol-impaired driving continues to be one of the most significant problems in roadway safety. In 2020, the most recent year for which complete data were available, NHTSA's Fatality Analysis Reporting System (FARS) estimated that 11,654 fatalities occurred in alcohol-impaired crashes (Stewart 2022).[35] This number represented about 30 percent of all traffic fatalities that year and a 14 percent increase over the 10,196 individuals who died as a result of alcohol-impaired crashes in 2019 (Stewart 2022). Recent research suggests that the problem of impaired driving is growing. Not only has there been an increase in alcohol sales (The FRED Blog 2020) and adult alcohol use during the COVID-19 pandemic (Pollard, Tucker, and Green 2020), but a NHTSA study found an increase in alcohol prevalence among crash-involved drivers admitted to participating trauma centers in 2020 (NHTSA 2021).

2.4.1.2 Crash Risk

It is widely recognized that alcohol impairment can begin with the first drink or a BAC of about 0.02 g/dL (NHTSA 2016), and the risk of being involved in a crash grows with higher BACs. One study sponsored by NHTSA showed a measurable effect of BAC on relative crash risk beginning at 0.04 g/dL and increasing exponentially at BACs above 0.10 g/dL. This study found an adjusted relative risk of crash involvement of 29.5 at BACs twice the legal limit (0.16 g/dL) and an adjusted relative risk of 81.8 for drivers at 0.20 g/dL (Blomberg and others 2009).[36] Thus, drivers with high BACs pose a vastly higher risk of causing a crash than unimpaired drivers.

2.4.1.3 Economic Cost

The estimated economic cost from alcohol-impaired crashes (involving alcohol-impaired drivers or alcohol-impaired nonoccupants, such as pedestrians or

[35] Any fatal crash involving a driver with a BAC of .08 g/dL or higher is considered an alcohol-impaired driving crash. BAC test results are not reported for many drivers involved in fatal crashes. In 2019, only 42 percent of drivers involved in fatal crashes were tested for alcohol. Each state or local jurisdiction has its own guidelines for when to administer BAC tests in fatal crashes. To address the missing data issue, NHTSA uses a statistical model to estimate the missing BAC of the driver.

[36] *Relative risk* is the likelihood of an occurrence (a crash) after exposure to a risk variable (alcohol consumption) as compared with the likelihood of its occurrence in a control or reference group (sober driver). An adjusted relative risk of 29.5 would mean that a driver with a BAC of 0.16 g/dL would be 29.5 times more likely to crash than a driver with a BAC of 0.00 g/dL (that is, a sober driver). A driver with a BAC of 0.20 g/dL would be 81.8 times more likely to be involved in a crash than a driver with a BAC of 0.00 g/dL.

bicyclists) is $44 billion annually (Blincoe and others 2014).[37] These costs represent the tangible losses that result from motor vehicle crashes.[38] However, in cases of serious injury, such costs fail to capture the value of lost quality of life. When quality-of-life valuations are considered, the total value of societal harm from alcohol-impaired driving crashes is $201.1 billion per year (Blincoe and others 2014).

2.4.2 Efforts to Reduce Alcohol-Impaired Driving

2.4.2.1 Background

During the 1980s and 1990s, considerable effort was dedicated to addressing alcohol-impaired driving. Advocacy groups like Remove Intoxicated Drivers (RID), established in 1978, and Mothers Against Drunk Driving (MADD), established in 1980, took lead roles in changing American perceptions about the acceptability of driving after drinking and in advocating meaningful legislative changes to keep drunk drivers off the road. Efforts undertaken across the United States to address alcohol-impaired driving and reduce the incidence of alcohol-impaired fatalities since the 1980s include the following:

- Nationwide “zero-tolerance laws” that set per se BAC levels between 0.00 and 0.02 g/dL for drivers younger than 21;
- Nationwide per se BAC limit of 0.08 g/dL for drivers age 21 and older;
- Nationwide per se BAC limit of 0.04 g/dL and random drug and alcohol testing for commercial drivers;
- Increased number of states with administrative license suspension and revocation laws and increased penalties for repeat offenders and drivers with high BAC levels;
- Increased use of high-visibility enforcement, including media campaigns and sobriety checkpoints;
- Increased availability of alcohol screening, intervention, and treatment programs for DUI offenders and for individuals with alcohol-use problems;[39]

[37] This estimate is based on the cost of alcohol-impaired driving crashes in 2010 (the most recent year for which cost data were available).

[38] Included in the economic cost estimate are loss of productivity, workplace losses, legal and court expenses, medical costs, emergency medical services, insurance administration, congestion, and property damage.

[39] The terms *DUI* and *driving while intoxicated (DWI)* generally refer to similar offenses and are often used synonymously. DUI can refer to driving under the influence of drugs, including alcohol, while DWI usually refers to driving while intoxicated by alcohol alone.

- Laws holding alcohol servers and providers liable for serving underage or obviously intoxicated individuals ("dram shop laws"), and responsible beverage service practices to prevent over-service or service to underage persons;
- Social host liability laws that impose civil liability on individuals in a noncommercial setting who serve alcohol to underage and intoxicated adults if the hosted drinker is subsequently involved in an alcohol-related crash;
- Vehicle sanctions for driving while intoxicated (DWI) offenders, such as vehicle or license plate impoundment;
- DWI courts, which are designed to address the alcohol problems of repeat offenders and take a comprehensive approach to change offender behavior;
- 24/7 sobriety programs that use technologies to monitor offender sobriety routinely or continuously; and
- Increased use of alcohol ignition interlock devices.

2.4.2.2 Recent NTSB Efforts

In December 2012, the NTSB issued a special investigation report concerning wrong-way driving on limited access highways (NTSB 2012a). Alcohol-impaired driving was identified as the leading cause of wrong-way crashes, and the report contained safety recommendations related to alcohol ignition interlocks and vehicle-integrated alcohol detection technologies that are discussed in section 2.4.3.

In May 2013, the NTSB adopted the safety report *Reaching Zero: Actions to Eliminate Alcohol-Impaired Driving* (NTSB 2013). The report was the culmination of a multiyear NTSB effort focused on the problem of alcohol-impaired driving. It addressed the necessity of implementing all the following elements to achieve meaningful reductions in alcohol-impaired driving crashes: stronger laws, improved enforcement strategies, innovative adjudication programs, and accelerated development of vehicle-integrated alcohol detection technologies. Specifically in the report, the NTSB issued safety recommendations in the following areas:[40]

- Reducing the per se BAC limit to 0.05 g/dL or lower for all drivers;
- Conducting high-visibility enforcement of impaired driving laws and incorporating passive alcohol sensing technology into enforcement efforts;

[40] The full text of these recommendations may be found in the NTSB's Reaching Zero report.

- Expanding the use of in-vehicle technologies to prevent operation by an impaired driver;
- Using DWI courts and other programs to reduce recidivism by repeat DWI offenders; and
- Establishing measurable goals for reducing impaired driving and tracking progress toward those goals.

2.4.2.3 Persistence of the Problem

Over the past four decades, the number of lives lost per year in alcohol-related crashes has dropped substantially. However, most of this reduction took place during the 1980s and early 1990s; since then, progress has been made but the advances have been incremental, and recent data show that impaired driving crashes are increasing. (See figure 10.) Since 2000, more than 230,000 people have lost their lives in crashes involving alcohol-impaired drivers, and these crashes continue to account for nearly 30 percent of all traffic fatalities (National Center for Statistics and Analysis 2020).

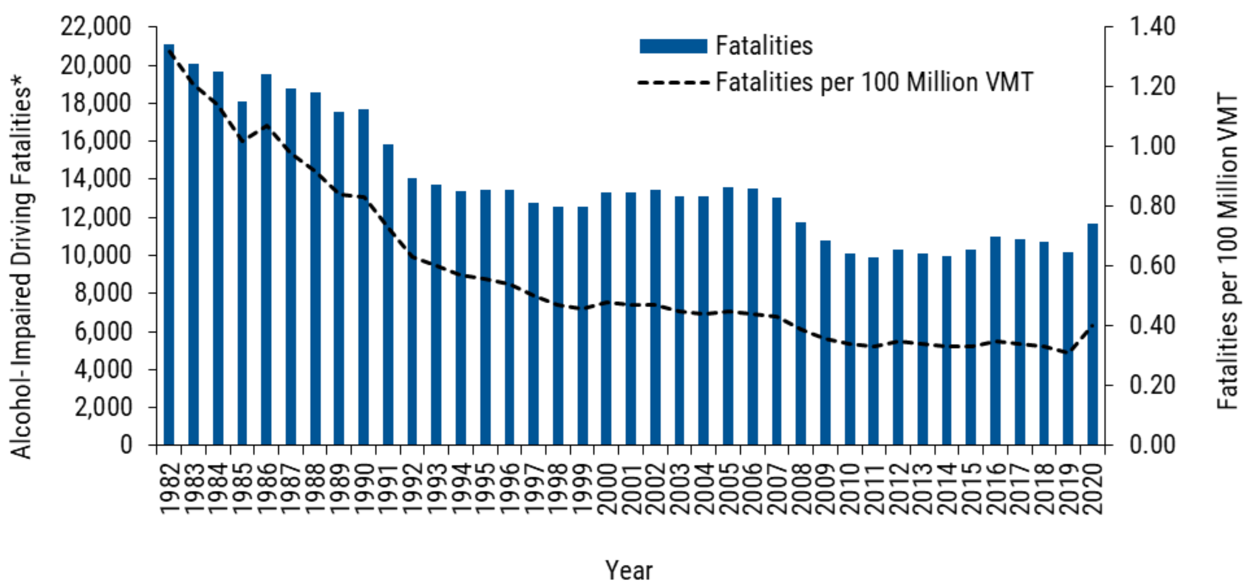

Figure 10. Impaired driving fatalities and fatality rates for 1982 through 2020. (As stated earlier, NHTSA considers any fatal crash involving a driver with a BAC of .08 g/dL or higher an alcohol-impaired driving crash. "VMT" stands for vehicle miles traveled.) (Sources: Traffic Safety Facts: 2020 Data: Alcohol-Impaired Driving and Reaching Zero: Actions to Eliminate Alcohol-Impaired Driving [NTSB 2013])

Reducing alcohol-impaired driving injuries and fatalities will require a system designed to address the innately faulty decision-making of those who drive while impaired by alcohol. For many drivers who choose to drive while impaired, traditional countermeasures have limited effect. Such individuals may persist in choosing to drive while impaired despite being fully aware that alcohol-impaired driving can be extremely dangerous. In a recent AAA Foundation for Traffic Safety survey of motorists evaluating American drivers' values and viewpoints on traffic safety, 94 percent of drivers acknowledged that drinking so much alcohol that they might be over the legal limit to drive was extremely or very dangerous (AAA Foundation for Traffic Safety 2020). At the same time, almost 10 percent of survey respondents admitted to engaging in this dangerous behavior in the preceding 30 days.

When it comes to alcohol-impaired driving, there is a disconnect between some drivers' attitudes and their behaviors, and many traditional countermeasures have limited effect under these circumstances and for such individuals. In the Avenal crash, for example, the SUV driver was driving without a license, he was operating the vehicle without the permission of the registered owner (his wife), and he drank an impairing amount of alcohol before driving. Moreover, the crash occurred on New Year's Day, a holiday when law enforcement is generally known to apply maximum enforcement efforts to catch impaired drivers.[41] Given these choices on the part of the SUV driver, countermeasures such as lower BAC laws, education and media campaigns, and administrative license suspensions, as well as other indirect actions, would most likely not have altered his decision to drive while impaired.

Because people who are impaired by alcohol often have difficulty making appropriate decisions or identifying their level of impairment, interventions that do not require decision-making by impaired drivers are needed to protect the motoring public. For this reason, accelerating the implementation of in-vehicle alcohol detection technology that can prevent or limit an alcohol-impaired driver's operation of a motor vehicle, no matter their mental state, is vital to improve road safety.

2.4.3 Vehicle-Integrated Passive Alcohol Detection Technology

2.4.3.1 Background

The NTSB actively advocates for a Safe System approach that aims to eliminate fatal and serious injuries for all road users. The approach does so through a holistic view of the road system that accepts the fact that drivers make poor decisions and errors; this approach identifies methods to reduce or eliminate the consequences of these errors. Taking this approach, safe vehicles should be equipped with passive

[41] The CHP initiated a statewide, high-visibility law enforcement campaign known as a "maximum enforcement period" for this holiday interval. The campaign was widely publicized in the press and on social media and ran from 6:00 p.m. local time on Thursday, December 31, 2020, until midnight on Sunday, January 3, 2021.

safety technologies to prevent or limit motor vehicle operation if a person is determined to drive while impaired by alcohol.

Passive safety technologies are generally integrated into system design; the technologies come pre-installed and go into effect without the individual having to activate them—air bags, for example, are a passive safety technology. Active safety technologies, on the other hand, require an individual to take a definite action to engage them. An example of an active safety technology is the seat belt; drivers must secure their belts each time they get into the vehicle to obtain the safety benefit. The success of the active safety approach depends on broad public acceptance and individual user action. By contrast, passive approaches work automatically, without the need for individual decision-making or action. Consequently, passive safety approaches have more certain safety outcomes.

Automobile manufacturers have been researching and developing a vehicle-integrated passive alcohol detection technology that measures a driver's BAC without requiring any action by the driver, and if it detects alcohol above a predetermined BAC threshold, it prevents the vehicle from moving. This type of technology is considered a direct measurement system. The automobile industry is also developing indirect measurement systems using in-vehicle cameras and sensors to detect and limit vehicle operation if impairment is detected. Indirect measurement systems infer driver impairment, using information from a network of sensors on the vehicle rather than measure physiological indicators such as BAC. By necessity, indirect measurement systems must allow a certain amount of impaired driving to occur in order to assess the driver's degree of impairment and determine whether it exceeds established legal limits or safe driving parameters. The following sections will discuss the current state of direct measurement systems (section 2.4.3.2), indirect measurement systems (2.4.3.3), and the need for additional action by NHTSA and manufacturers (section 2.4.3.4).

2.4.3.2 Alcohol Detection Direct Measurement Systems

For more than a decade, most of the automobile industry's efforts have been focused on developing a direct measurement system, known as the Driver Alcohol Detection System for Safety (DADSS), to detect alcohol-impaired drivers. In 2008, NHTSA and an automotive industry-funded nonprofit group, the Automotive Coalition for Traffic Safety (ACTS), formed a public-private partnership to develop noninvasive, passive, vehicle-integrated technologies to prevent alcohol-impaired driving.[42] Two passive technologies are under development: a breath-based system

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[42] ACTS represents motor vehicle manufacturers responsible for about 99 percent of light vehicle sales in the United States (Zaouk and others 2019). Manufacturers include BMW, Fiat Chrysler, Ford, GM, Honda, Hyundai, Jaguar, Kia, Land Rover, Mazda, Mercedes Benz, Mitsubishi, Nissan, Porsche, Subaru, Toyota, Volkswagen, and Volvo.

and a touch-based system that would prevent a driver with a BAC at or above a predetermined BAC limit from moving the vehicle. As part of the development process, researchers established system specifications for both the breath- and touch-based technologies (Biondo, Zouk, and Sundarajan 2017). Table C-1 in appendix C contains the design specifications. The specifications were created with the assumptions that, for vehicle-integrated alcohol-detection technologies to be acceptable to the driving public, they must be unobtrusive, reliable, and durable; they must require minimal maintenance; and they must not interfere with the driving task (Ferguson and others 2009).

The passive breath-based device is designed to use spectrometry to measure the alcohol concentration in a driver's exhaled breath.[43] The device transmits infrared light toward the driver and assesses the alcohol concentration. The breath-based device does not require skin contact to assess the driver's BAC, and the vehicle will not move if the driver's BAC is at or higher than a predetermined BAC limit.[44]

The passive touch-based technology is also designed to use spectrometry to measure alcohol concentration but in the driver's skin tissue. When the driver's finger is in contact with the device's optical touch pad, infrared light propagates into the skin tissue, and the touch pad collects a sample of the light reflected back from the tissue surface, from which the unique chemical and tissue structure information contained in the light can be read and the alcohol concentration determined (Zaouk and others 2019). The technology is envisioned to be integrated into the push button of new vehicles so that a driver's BAC will be measured when they use their finger to start their vehicle; if the driver's BAC is at or above a predetermined BAC level, the technology will prevent the vehicle from moving.

The original DADSS program plan anticipated that a passive alcohol detection system would be available in a prototype vehicle by the end of 2013 (Ferguson and others 2009). Although progress has been made in developing the two passive technologies, neither the breath-based nor the touch-based systems have yet reached the stage where they can be evaluated against all the DADSS specifications (described in appendix C) that are required for prototype vehicle implementation and on-road testing. In discussions with NHTSA staff, DADSS researchers have reported that the development team has identified a passive breath alcohol detector

[43] *Spectrometry* is the measurement of the interactions between light and matter (for example, breath particles and human tissue).

[44] Sensors are generally set to detect alcohol at or above .08 g/dL to correspond with states' per se legal limits. Manufacturers can change settings to a lower or higher BAC level, depending on the desired application. For commercial applications, a zero-tolerance setting may be desired. As an example of a manufacturer-established setting, Schneider Trucking is pilot testing a directed breath system set at a BAC level of .025 g/dL.

with high sensitivity, but it is not currently available in mass quantities.[45] They also noted that the passive breath-based system may have problems with ambient air dilution (for example, due to airflow through open vehicle windows) and in differentiating imbibed from non-imbibed sources of alcohol, such as hand sanitizer, perfumes, mouthwash, etc. (Smith, Doerzaph, and Hankey 2015). One of the biggest challenges to the passive breath-based technology concerns placement of the sensor (or sensors) to ensure that the system can measure the driver's "breath plume."

Regarding the touch-based technology, the biggest challenge has been trying to shrink the size of the system so that it will work in an automotive setting while maintaining data quality (accuracy, precision, and speed, as outlined in the system specifications). Current research efforts are focused on maximizing the amount of infrared light directed to and returned from human tissue (in the capillary bed of the fingertip and/or the dermis layer of the palm).

In addition to the passive systems in development, the DADSS research program has expanded its scope to include "directed-breath" systems. Current prototypes of in-vehicle breath-based systems require directed breath—that is, a mild exhalation of breath toward a sensor, similar to blowing out a candle—rather than unforced exhalation. Directed-breath technology does not meet the stated objectives of the DADSS research program that the technology be passive and noninvasive.

Passive breath-based and touch-based systems are still being evaluated in the laboratory environment. Based on information provided by NHTSA and ACTS, a passive breath-based system for all vehicles is anticipated to be available for commercial licensing in 2024. Assuming a post-licensing development period of at least 24 months, this would mean that a passive breath-based system would most likely not be available for non-fleet passenger vehicles until 2026.

The NTSB has supported the development of alcohol-detection direct measurement systems for over a decade. In 2012, as part of the NTSB's special investigation of wrong-way driving crashes, we recommended that NHTSA and ACTS work together to take the following actions (NTSB 2012a):

> Work with the Automotive Coalition for Traffic Safety, Inc., to accelerate widespread implementation of DADSS technology by (1) defining usability testing that will guide driver interface design and (2) implementing a communication program that will direct driver education and promote public acceptance. (H-12-43)

[45] Refer to the *In-Vehicle Alcohol-Impaired Driving Detection* report in the public docket for this crash (NTSB case number HWY21FH003).

> Work with the National Highway Traffic Safety Administration to accelerate widespread implementation of DADSS technology by (1) defining usability testing that will guide driver interface design and (2) implementing a communication program that will direct driver education and promote public acceptance. (H-12-48)

The primary focus of these recommendations was to accelerate the widespread implementation of passive in-vehicle alcohol detection technology. In 2013, NHTSA informed the NTSB that the DADSS research program was proceeding on schedule and projected that, by early 2014, a research vehicle that incorporated both the passive breath- and touch-based systems would be complete. On the basis of this information, the NTSB classified both recommendations "Open—Acceptable Response." The research program ultimately failed to meet this projected timeline. In 2017, the NTSB classified Safety Recommendation H-12-43 to NHTSA "Open—Unacceptable Response." (The status of Safety Recommendation H-12-48 to ACTS remained "Open—Acceptable Response.") NHTSA sent a March 4, 2022, letter to the NTSB, providing an update on actions it and ACTS had taken to fulfill Safety Recommendations H-12-43 and -48 as part of a multiyear agreement between the two organizations concerning research on the DADSS technology. The March 2022 update also detailed work that ACTS had undertaken in the areas of testing, analysis, and communication. However, the interface testing and communications activity conducted by the two groups has been very limited to date. Moreover, in the 10 years since we first issued the recommendations, neither passive (breath- and touch-based) DADSS technology has reached sufficient development for vehicle implementation or field testing. Based on the slow pace of development and the failure of the DADSS research program to meet projected deployment timelines, the NTSB classifies Safety Recommendations H-12-43 and -48 "Closed—Unacceptable Action."

Although the NTSB is closing these decade-old safety recommendations, we continue to strongly support the research and development of vehicle-integrated passive alcohol detection technology. It has been estimated that direct measurement technologies that would keep drivers with any BAC (above zero) off the road could prevent nearly 12,000 deaths per year, while systems that would keep drivers with BACs of .08 g/dL and above off the road could prevent more than 9,000 deaths per year (Farmer 2021).[46] Therefore, the NTSB concludes that vehicle-integrated passive alcohol detection technologies that prevent impaired drivers from operating their

[46] The research study noted that the lifesaving benefits of the technology would not be immediate. Even if the technology were required as standard equipment in all new vehicles, it would take 12 years to achieve enough market penetration to reach even half of the system's lifesaving potential. Within 3 years of a mandate, it is expected that the annual lives saved would be 1,000–1,300. Within 6 years, about 2,000–2,600 lives would be saved per year and, within 12 years, about 4,600-5,900 lives would be saved per year.

vehicles have significant lifesaving potential; however, development of the technologies has been slow, and action is needed to accelerate progress toward the implementation of these technologies.

2.4.3.3 Alcohol Detection Indirect Measurement Systems

The automobile industry is engaged in a technological transformation and is making substantial advancements in developing the foundational building blocks for automated vehicles and in designing and deploying vehicle-based technology to compensate for driver errors. As advanced driver assistance systems (ADAS), in-vehicle cameras and sensors, and driver monitoring systems are improved, these technologies have the potential to reduce alcohol-impaired driving crashes in the future.

To learn more about potential lifesaving technologies, in late 2020, NHTSA issued a request for information (RFI) soliciting information on available and late stage technology under development for impaired driving detection and mitigation.[47] More specifically, NHTSA requested information about technologies that can detect degrees of driver impairment through a range of approaches, including the following: (1) technologies that can monitor driver action; (2) technologies that can directly monitor driver impairment; (3) technologies that can monitor a driver's physical characteristics, such as eye tracking or other measures of impairment; and (4) technologies or sensors that directly measure a driver's physiological indicators that are already linked to forms of impaired driving (for example, BAC).

Responses to the RFI included comments from the Alliance for Automotive Innovation; safety advocacy groups (MADD, the National Safety Council, and Advocates for Highway and Auto Safety); and numerous vehicle component manufacturers.[48] A large majority of responses addressed potential technologies related to driver performance (behavior) monitoring systems and driver state monitoring systems. Driver performance monitoring systems are often associated with ADAS; they evaluate a driver's behavior through embedded vehicle sensors registering steering wheel input, lane-keeping/drift, acceleration/decelerations,

[47] Refer to NHTSA Docket No. 2020-0102 at Regulations.gov, accessed August 5, 2022.

[48] MADD's submission to the RFI included 241 technologies with a described potential to prevent or mitigate alcohol-impaired driving.

vehicle speed, turn radius, traffic signal response time, and hands on the wheel.[49] Driver state monitoring systems usually rely on in-vehicle sensors, such as cameras, to measure a person's face, eyes, or head for signs of impairment (that is, glance behavior, blink behavior, head/body position, pupil dilation, emotions, secondary task engagement, heart rate, breathing, etc.). Most of the research related to driver monitoring systems has focused on detecting signs of distraction and fatigue. Additional research is needed to determine these systems' capabilities and limitations concerning the detection of an individual's alcohol impairment.

Detecting and distinguishing a person's specific state of impairment is a complex task and is hindered by the challenges of individualistic responses, the complexities of the moving environment, and the relatively immature state of vehicle sensor technology. Driver monitoring systems infer rather than physiologically assess driver impairment. Moreover, driver monitoring systems, by design, must allow a certain amount of impaired driving to take place to enable the system to make an assessment regarding the driver's degree of impairment. In the Avenal crash, for example, the high-BAC SUV driver crashed less than 1.5 miles after beginning his drive away from the gathering. A very robust driver monitoring system (not yet developed) would be needed to prevent a similar crash from recurring in the future. Further, unlike a fatigued or distracted driver, an alcohol-impaired driver may be less responsive to vehicle-based warnings and moderate interventions. Extreme interventions involving the safe cessation of a moving vehicle's operation will be difficult for current ADAS systems to achieve, and these challenges will need to be overcome as part of NHTSA's continued research into other technologies that prevent alcohol-impaired driving.

The NTSB strongly supports ongoing research to develop new safety technologies. One of the primary benefits of technologies such as driver monitoring systems is that they have the potential to detect driver impairment from alcohol regardless of the BAC level, in addition to impairment from other drugs, fatigue, distraction, and other factors. It is clear, however, that many challenges remain in developing technology suitable for combatting alcohol-impaired driving. The NTSB concludes that, although automobile manufacturers are developing driver monitoring systems that can assess a driver's state, performance, and behavior, additional effort is needed to determine these systems' accuracy in detecting alcohol

[49] In the NTSB's report on a crash involving a distracted driver operating a vehicle with partial automation in Mountain View, California, we recommended that NHTSA work with SAE International to develop performance standards for driver monitoring systems to minimize driver disengagement, prevent automation complacency, and account for foreseeable misuse of the automation. An accompanying recommendation called for NHTSA to require that all new passenger vehicles with Level 2 automation be equipped with a driver monitoring system that meets these standards. Refer to Safety Recommendations H-20-3 and -4 for additional details (NTSB 2020).

impairment, their effectiveness in providing driver warnings, and what intervention strategies they should employ when active driving is to be halted.

2.4.3.4 Additional Action Needed

Immediate action is needed to meaningfully reduce the incidence of impaired driving injuries and fatalities on our nation's highways. This includes a thorough evaluation and deployment of advanced drunk and impaired driving prevention technology. Recognizing the serious danger posed by drunk drivers to public safety, Congress issued legislation that will require installation of the technology on all new vehicles.[50] In the legislation, the term "advanced drunk and impaired driving prevention technology" is used to refer to a system that can passively monitor the performance of a motor vehicle driver, as well as prevent or limit vehicle operation if impairment is detected and/or can passively and accurately detect whether the driver's BAC is equal to or greater than 0.08 g/dL and can prevent or limit motor vehicle operation if a BAC at or above this level is detected. The legislation requires that, within 3 years, the US Department of Transportation (DOT) issue a final rule prescribing a Federal Motor Vehicle Safety Standard (FMVSS) that requires all new passenger vehicles to be equipped with advanced impaired driving technology meeting such specifications.

The NTSB concurs with Congress that vehicle-integrated passive alcohol detection devices that prevent or limit impaired drivers from operating their vehicles should be incorporated into vehicles as soon as is reasonable and practicable. As recently as June 2022, members of Congress formed an independent technical working group to focus on fulfilling this mandate.[51] Given that the technology has the potential to save thousands of lives per year, the NTSB joins Congress in pressing for progress in this area and recommends that NHTSA require that all new vehicles be equipped with passive vehicle-integrated alcohol impairment detection systems, advanced driver monitoring systems, or a combination thereof; the systems must be capable of preventing or limiting vehicle operation if driver impairment by alcohol is detected.

[50] Refer to the Infrastructure Investment and Jobs Act, section 24220, (accessed June 15, 2022) for additional details.

[51] On June 14, 2022, US Senator Ben Ray Luján (D-New Mexico), US Representative Debbie Dingell (D-Michigan), and multiple automotive safety professionals announced the formation of an independent technical working group to assist with implementation of advanced impaired driving prevention technology, as mandated by Congress. The working group consists of professionals with knowledge of vehicle safety technologies, the FMVSS regulatory process, and public health initiatives. The working group will be co-chaired by MADD's chief government affairs officer and a distinguished scholar at the Johns Hopkins Center for Injury Research and Policy. For more information, see the press release on the working group issued by Senator Luján's office (accessed June 15, 2022).

As noted previously, most of the automobile industry's efforts to develop impaired driving prevention technology have focused on DADSS technology, which measures a driver's BAC. In January 2021, the Alliance for Automotive Innovation responded to NHTSA's RFI on impaired driving technology and reaffirmed its position that "DADSS research should be supported and completed as an agency priority."[52] The Alliance is an association that represents the manufacturers of nearly 98 percent of the new cars and light trucks sold in the United States, as well as original equipment suppliers.

Given that numerous other technologies, such as driver monitoring systems, offer promise in preventing impaired driving crashes, it is essential that the automobile industry seek innovative ways to adapt existing technologies, and systems in development, to combat alcohol-impaired driving. Therefore, the NTSB recommends that the Alliance for Automotive Innovation inform its members of the Avenal, California, crash and encourage manufacturers to accelerate development and prioritize deployment of advanced impaired driving prevention technology and to seek innovative ways to adapt existing technologies, such as driver monitoring systems, to combat alcohol-impaired driving.

2.5 Technology to Prevent Speeding-Related Crashes

The SUV driver in the Avenal crash was traveling between 88 and 98 mph, about 35 mph above the posted speed limit of 55 mph. As discussed in section 2.2.2, this high rate of speed contributed to the crash severity and lack of survivability for occupants of both vehicles. The NTSB has long been concerned about speeding-related crashes, and "Implement a Comprehensive Strategy to Eliminate Speeding-Related Crashes" is an issue area on the NTSB's current Most Wanted List of Transportation Safety Improvements.[53] This section of the report will review the speeding-related crash problem, countermeasures to reduce crashes caused by speeding, and the need to increase implementation of safe vehicle technologies that have been shown to be effective at reducing speeding.

2.5.1 Scope of the Speeding-Related Crash Problem

Speeding—exceeding a speed limit or driving too fast for conditions—is one of the most common factors associated with motor vehicle crashes in the United States (NTSB 2017). In 2020, there were 11,258 fatalities in crashes in which at least one driver was speeding, accounting for about 29 percent of total traffic fatalities for the

[52] Refer to the Alliance for Automotive Innovation response to NHTSA Docket No. 2020-0102 at Regulations.gov, accessed August 5, 2022.

[53] Refer to Implement a Comprehensive Strategy to Eliminate Speeding-Related Crashes, accessed June 15, 2022.

year. This represented an increase from the 9,592 speeding-related fatalities in 2019 (Stewart 2022), which accounted for about 26 percent of total traffic fatalities that year. Speed increases crash risk in two ways: (1) it increases the likelihood of the driver being involved in a crash, and (2) it increases the severity of injuries sustained by all road users involved in the crash. Higher vehicle speeds lead to larger changes in velocity in a crash, and these velocity changes are closely linked to injury severity. The crash involvement rate increases with speed because increased speed reduces the available time for a driver to receive and process information to respond to the crash situation (American Association of State Highway and Transportation Officials 2011). Further, the vehicle's stopping distance and the chance of a vehicle being driven off the road both increase with vehicle speed (Srinivasan and others 2006). For information on fatal speed-related crashes in recent years, see table 4.

Table 4. Total traffic fatalities and speeding-related traffic fatalities, 2011–2020.

Year	Total Fatalities	Speeding-Related Fatalities	% Speeding Related
2011	32,479	10,001	31%
2012	33,782	10,329	31%
2013	32,893	9,696	29%
2014	32,744	9,283	28%
2015	35,484	9,723	27%
2016	37,806	10,291	27%
2017	37,473	9,947	27%
2018	36,835	9,579	26%
2019	36,355	9,592	26%
2020	38,824	11,258	29%

Source: NHTSA *Traffic Safety Facts*, June 2022 (DOT HS 813 320)

2.5.2 Countermeasures to Reduce Speeding-Related Crashes

In 2017, the NTSB released the study *Reducing Speeding-Related Crashes Involving Passenger Vehicles*, which included strategies for addressing speeding (NTSB 2017). Traditional countermeasures have been grouped into three categories: engineering, enforcement, and education (Donnell and others 2009). Engineering refers to roadway infrastructure changes.[54] Enforcement refers to strategies to ensure

[54] Engineering countermeasures include variable speed limits, speed feedback signs, speed humps, and roundabouts at intersection locations.

that drivers obey existing laws.[55] Education refers to efforts to inform drivers and other stakeholders about traffic safety laws and the consequences of risky behavior.[56]

Because of the circumstances of the Avenal crash, it is unlikely that traditional countermeasures would have been effective in slowing the speed of the SUV, due to the driver's level of impairment and his propensity to engage in risky and illegal driving behavior. Additionally, with respect to enforcement, the rural site of the crash would not be ideal for automated speed enforcement, given the location's relatively low traffic volume and limited crash history. From a Safe System perspective, emerging safe vehicle technologies, such as intelligent speed adaptation (ISA), show promise in preventing high-risk impaired drivers from speeding.

2.5.3 Intelligent Speed Adaptation

2.5.3.1 Background

ISA is a system designed to help ensure that vehicle speed does not exceed a safe or legally enforced speed. ISA systems determine the speed limit in effect by comparing a vehicle's global positioning system (GPS) location to a database of posted speed limits and/or using onboard cameras to recognize speed limit signs (Goodwin and others 2015). In the NTSB speeding study (NTSB 2017), we described three levels of ISA:

- Open ISA: An advisory system that issues visual or aural alerts to the driver when the speed limit is exceeded; the driver is responsible for slowing the vehicle.
- Half-Open ISA: A system that increases back pressure on the accelerator when the speed limit is exceeded, making it more difficult (but not impossible) to exceed the speed limit.
- Closed ISA: A system that electronically limits the speed of a vehicle, preventing drivers from exceeding the speed limit.

The primary advantage of ISA compared to conventional speed limiters (also known as speed governors) is that the limiting speed is the posted speed limit in a particular location, rather than a single, fixed speed. Conventional speed limiters have been used voluntarily by US commercial truck and bus fleets for the safety and fuel efficiency benefits they provide, and other countries have required their use on trucks and buses since the 1990s (NTSB 2012b). However, because conventional

[55] Enforcement countermeasures include regular traffic patrols, high visibility enforcement, and automated speed enforcement.

[56] Education countermeasures include driver education courses, public awareness campaigns, and judicial education.

speed limiters cannot prevent speeding in locations where the speed limit is lower than the governed speed, the NTSB has previously recommended that heavy vehicles, including trucks, buses, and motorcoaches, be equipped with advanced speed-limiting technology such as ISA (NTSB 2012b, NTSB 2015, NTSB 2022).

Many manufacturers offer open ISA capabilities for the US passenger vehicle market. The NTSB speeding study provided examples of automobile manufacturers offering ISA technology at that time (NTSB 2017). Many of the manufacturers market ISA technology toward teen drivers and their parents; consequently, they only make the features available for a subset of their models and only when buyers are purchasing certain options packages (such as those that include a GPS navigation system). Most systems offered by US manufacturers do not yet meet the definitions of half-open or closed ISA.

ISA has been studied extensively internationally and, to a lesser degree, in the United States (Blomberg and others 2015; De Leonardis, Huey, and Robinson 2014; Regan and others 2006; Várhelyi and others 2004). The studies have generally found ISA to be effective in reducing speeding. The effectiveness of a particular ISA system depends on its underlying speed limit detection technology. For those systems that rely on GPS maps, the speed limit data must be complete, accurate, and timely. For those systems that rely on sign-detecting cameras, performance is dependent on weather conditions, lighting conditions, obstructions (such as vegetation or other vehicles), speed limit sign format, and sign placement.

Because closed ISA systems can reduce vehicle speed independent of driver action or decision, had the Avenal SUV been equipped with such a system, the SUV might have been traveling at a slower speed, which might have prevented the crash or at least mitigated the severity of the crash outcome. Further, although the pickup truck was not traveling nearly as far above the speed limit as the SUV, an ISA system on the pickup truck might have mitigated some crash forces. Therefore, based on the circumstances of the Avenal crash and available research on ISA systems, the NTSB concludes that ISA is an effective vehicle technology to reduce speeding, and the severity of the Avenal crash might have been mitigated if the vehicles had been equipped with closed ISA systems that electronically limited their speeds.

2.5.3.2 European Union Implementation of ISA

Beginning in July 2022, ISA will be mandatory for all new models of vehicles introduced in the European Union.[57] The recently adopted regulation provides four options for providing feedback to the driver, from which car manufacturers will be free to choose: (1) cascaded acoustic warning, (2) cascaded vibration warning,

[57] Refer to EU Regulation 2019/2144—Automotive Type Approval General Safety Requirements.

(3) haptic feedback through the acceleration pedal, or (4) speed control function. The first two feedback options do not directly intervene but only provide warnings to the driver (first optic and then, if there is no response from the driver, a delayed acoustic/vibrating warning). The other possible feedback options rely on the accelerator pedal's restoring force—the pedal will gently push back against the driver's foot to make the driver aware of excess speed and to slow the vehicle. The driver can ignore this feedback and override the system by pressing down harder on the acceleration pedal.

In addition to this new regulation, the European New Car Assessment Program (Euro NCAP) promotes the installation of speed adaptation systems that help drivers control their speed.[58] Euro NCAP assesses ISA functions by evaluating the following: how well the system informs the driver of the present speed limit, the effectiveness of warnings to the driver when the car's speed is above the set speed threshold, and the system's ability to prevent the car from exceeding the set speed. Euro NCAP also examines the functionality of the system to make sure that it can be used without undue distraction to the driver. For the more robust systems that actively control the speed, tests are performed to ensure that the system does this accurately.

In contrast to the European Union, the United States has no plans to develop performance standards for, or to require the installation of, ISA on new vehicles sold in this country. Additionally, ISA is not part of the US NCAP. In 2017, as part of the NTSB study on reducing speed-related crashes (NTSB 2017), the NTSB recommended that NHTSA:

> Incentivize passenger vehicle manufacturers and consumers to adopt intelligent speed adaptation (ISA) systems by, for example, including ISA in the New Car Assessment Program. (H-17-24)

In response to this recommendation, NHTSA stated that its research did not fully support ISA as a safety system that should be included in NCAP.[59] Citing two research studies, NHTSA questioned the effectiveness of ISA and stated that "consumers are unlikely to use the information we provide about ISA in a way that will encourage manufacturers to provide the equipment." Contrary to this assessment,

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[58] Refer to Euro NCAP Speed Assistance Systems (accessed June 15, 2022) for additional information.

[59] (a) Refer to Safety Recommendation H-17-24 (accessed June 15, 2022) to learn more about this recommendation. (b) In March 2022, NHTSA published a request for comments (RFC) on NCAP. The RFC queried whether ISA should be included in NHTSA's proposed long-term NCAP roadmap. The RFC also included questions regarding types of warnings and interventions, thresholds for permissible speeding, protocols to be considered when evaluating ISA functionality, information regarding consumer interest and feedback, and other technologies to prevent excessive speeding. The NTSB provided comments in response to this RFC, which may be found at the following link: NTSB response to NCAP RFC. (Both weblinks accessed June 15, 2022.)

the NTSB's speeding study found that at least one automobile manufacturer had stated that the inclusion of ISA in the European NCAP was a primary reason it had developed ISA capability for its vehicles sold in Europe. In addition, safety rating programs like NCAP have been shown to increase the sales of high-rated vehicles relative to lower-rated vehicles (Insurance Institute for Highway Safety 2013).

Based on NHTSA's expressed intent to assess ISA systems as the technology matures and to develop a consumer information program to encourage adoption of such systems, rather than incentivizing manufacturers, the NTSB classified Safety Recommendation H-17-24 "Open—Acceptable Alternate Response" in March 2018. Since then, NHTSA has made no progress or plan toward encouraging consumers or passenger vehicle manufacturers to adopt ISA, or to include ISA in the US NCAP, as recommended; therefore, the NTSB reiterates Safety Recommendation H-17-24 to NHTSA and classifies it "Open—Unacceptable Response."

2.6 Need to Implement a Uniform Standard for Drug Toxicology Testing

Although the matter is not causal or contributory in the Avenal crash, the NTSB determined during this investigation that there is a critical need to implement a uniform standard for drug toxicology testing. The Fresno County medical examiner's office performed autopsies on the two involved drivers. As part of the examination, Fresno County contracted with CVT to conduct postmortem toxicology testing on blood specimens for both drivers. The testing did not screen for the presence of cannabis, even though it is a commonly used impairing drug. In California, as in most states, local jurisdictions and medical examiners make their own decisions concerning drug testing for drivers who die in crashes. As a result, the list of tested-for drugs (and even the decision of whether to conduct postcrash drug testing) varies widely. This section will examine the lack of federal guidance for drug toxicology testing and ongoing efforts in California to standardize testing practices.

2.6.1 Federal Guidance

Collecting consistent postcrash drug data is critical to ensuring that policymakers have an accurate understanding of the prevalence of drug use among drivers. Consistent postcrash data also provide a reliable and valid marker with which to measure the effectiveness of laws, enforcement, education, and other countermeasures to address drugged driving. No federal guidance currently exists on what minimum set of drugs should be tested for, recommended methods for drug testing, or reporting thresholds for crash databases. Federal guidance would provide states and others involved in postcrash drug testing a benchmark with which to assess the effectiveness of their policy efforts to address drug-impaired driving. The NTSB concludes that, without common standards of practice for drug toxicology testing, policymakers lack critical information on the prevalence of drug use among drivers; the effectiveness of laws, enforcement, and education; and the utility of other countermeasures to address drugged driving.

In 2012, following an NTSB forum on "reaching zero" crashes from substance-impaired driving, we recommended that NHTSA take the following action:

> Develop and disseminate to appropriate state officials a common standard of practice for drug toxicology testing, including (1) the circumstances under which tests should be conducted, (2) a minimum set of drugs for which to test, and (3) cutoff values for reporting the results. (H-12-33)

In response to this safety recommendation, NHTSA informed the NTSB that it was developing a recommended standard of practice for drug toxicology testing. In 2016, NHTSA provided support for an effort to review and update a set of recommendations developed by the National Safety Council (NSC) Alcohol, Drugs, and Impairment Division for the toxicological investigation of drug-impaired driving cases and motor vehicle fatalities (D'Orazio and others 2021). The NSC report, which was part of a regularly produced survey of forensic toxicology laboratories in the United States and Canada, provided a set of recommendations concerning which drugs should be tested for (including THC, carboxy-THC, and 11-hydroxy-THC), as well as cutoff figures for analyses in blood, urine, and oral fluid (D'Orazio and others 2021).

In 2018, NHTSA established an expert working group on toxicology data collection to improve overall understanding of the national scope and prevalence of drug-impaired driving. The working group drafted guidance for the forensic toxicology community; however, the draft guidance was never shared with the public, and the working group stopped meeting in 2019.

Safety Recommendation H-12-33 is currently classified "Open—Acceptable Response." Although NHTSA has taken some steps to develop standards for drug toxicology testing, the agency has not made progress in disseminating information on this important safety issue to state officials. Therefore, the NTSB reiterates Safety Recommendation H-12-33 to NHTSA and classifies it "Open—Unacceptable Response."

2.6.2 California's Efforts to Standardize Drug Toxicology Testing Practices

In 2017, following California's passage of the 2016 Adult Use of Marijuana Act, which resulted in increased availability of legal cannabis, the state legislature identified the need to further evaluate the issue of impaired driving. The CHP formed an Impaired Driving Task Force (IDTF) for the purpose of developing recommendations for best practices, protocols, and other policies addressing issues related to impaired driving, including impairment from cannabis, prescription drugs, and other substances.

The IDTF met multiple times over several years and, in January 2021, released a report containing recommendations to prevent impaired driving, as well as to reduce and mitigate its effects (CHP 2021). A key finding of the task force was that current toxicology practices lack uniform standards, making it difficult to quantify and adequately understand the scope of driving under the influence of drugs in California.[60] The task force recommended that evidence collection processes be standardized, as well as that forensic toxicology laboratories be accredited by a nationally recognized accrediting body and follow the standards recommended by the NSC Alcohol, Drugs, and Impairment Division. The NTSB concludes that data on the prevalence of impairing drug use among crash-involved drivers would be more useful to policymakers if all forensic toxicology laboratories in California followed the standards recommended by the Alcohol, Drugs, and Impairment Division of the NSC.

To standardize their toxicology testing, toxicologists, law enforcement, and California lawmakers worked together in 2019 to introduce Assembly Bill 551 and Senate Bill 283. These bills were designed to address the statewide gaps in toxicology testing and improve standards of testing. The proposed legislation would have required coroners and medical examiners to obtain screening and confirmatory tests for specified drugs, as well as to include BAC and blood drug concentrations in the medical findings, when available. Despite its passing both legislative chambers, the governor vetoed the bill. In the governor's veto response letter, he stated that—

> County coroners currently have the authority to conduct the tests required by this bill, as well as for other substances not covered by this legislation, such as cannabis. Instead of creating a simple mandate for some drugs—and not other impairing substances—I believe it is best to allow coroners to exercise their professional judgment and determine when any such testing should occur.

[60] California has 58 counties that each make their own decisions about drug testing.

The California IDTF has identified the critical need for standardized drug toxicology testing, and the state legislature appears to be willing to pass legislation that addresses identified testing shortfalls. Until NHTSA develops and disseminates a common standard of practice for drug toxicology testing at the national level, the NSC's Alcohol, Drugs, and Impairment Division's report provides the recommended forensic testing standards that should address the concerns expressed by the governor in his veto response letter. Therefore, the NTSB recommends that the state of California enact legislation that requires forensic toxicology laboratories to follow the standards recommended by the NSC's Alcohol, Drugs, and Impairment Division; the legislation should include a provision requiring laboratories to update the testing protocol if additional federal guidance is provided.

3. Conclusions

3.1 Findings

1. None of the following were factors in the crash: (1) drivers' familiarity with their vehicles or the roadway, (2) medical conditions or fatigue, (3) cell phone use, (4) mechanical condition of either vehicle, (5) highway condition, or (6) weather.

2. The emergency response efforts were timely and adequate.

3. The sport utility vehicle driver's failure to keep his vehicle on the paved portion of the highway, in combination with his excessive speed, resulted in a loss of vehicle control when he oversteered while attempting to reenter the roadway.

4. Due to the high speed of the sport utility vehicle (SUV) and the short distance from where the SUV reentered the roadway to the impact location, the pickup truck driver had insufficient time to take evasive action to avoid the crash.

5. Although the driver of the sport utility vehicle and some occupants of the pickup truck were not appropriately restrained, it is unlikely that the crash was survivable, given the severity of the head-on collision, the significant vehicle intrusion, and the rapid spread of the postcrash fire in the pickup truck.

6. The sport utility vehicle driver's high level of alcohol intoxication contributed to his excessive speed and loss of vehicle control, resulting in the centerline crossover and head-on collision.

7. Although toxicology testing detected evidence of cannabis use by the sport utility vehicle driver, the National Transportation Safety Board was unable to determine whether the effects of cannabis use contributed to the driver's impairment.

8. Although cannabis was detected in the pickup truck driver's blood, given the limited time the pickup truck driver had to respond to the head-on approach of the sport utility vehicle, the effects of the pickup driver's cannabis use did not contribute to the crash.

9. Vehicle-integrated passive alcohol detection technologies that prevent impaired drivers from operating their vehicles have significant lifesaving potential; however, development of the technologies has been slow, and action is needed to accelerate progress toward the implementation of these technologies.

10. Although automobile manufacturers are developing driver monitoring systems that can assess a driver's state, performance, and behavior, additional effort is needed to determine these systems' accuracy in detecting alcohol impairment, their effectiveness in providing driver warnings, and what intervention strategies they should employ when active driving is to be halted.

11. Intelligent speed adaptation (ISA) is an effective vehicle technology to reduce speeding, and the severity of the Avenal crash might have been mitigated if the vehicles had been equipped with closed ISA systems that electronically limited their speeds.

12. Without common standards of practice for drug toxicology testing, policymakers lack critical information on the prevalence of drug use among drivers; the effectiveness of laws, enforcement, and education; and the utility of other countermeasures to address drugged driving.

13. Data on the prevalence of impairing drug use among crash-involved drivers would be more useful to policymakers if all forensic toxicology laboratories in California followed the standards recommended by the Alcohol, Drugs, and Impairment Division of the National Safety Council.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the Avenal, California, crash was the failure of the sport utility vehicle (SUV) driver to control his vehicle due to a high level of alcohol impairment. Contributing to the severity of the crash was the SUV driver's excessive speed.

4. Recommendations

4.1 New Recommendations

As a result of this investigation, the National Transportation Safety Board makes the following new safety recommendations.

To the National Highway Traffic Safety Administration:

> Require that all new vehicles be equipped with passive vehicle-integrated alcohol impairment detection systems, advanced driver monitoring systems, or a combination thereof; the systems must be capable of preventing or limiting vehicle operation if driver impairment by alcohol is detected. (H-22-22)

To the state of California:

> Enact legislation that requires forensic toxicology laboratories to follow the standards recommended by the National Safety Council's Alcohol, Drugs, and Impairment Division; the legislation should include a provision requiring laboratories to update the testing protocol if additional federal guidance is provided. (H-22-23)

To the Alliance for Automotive Innovation:

> Inform your members of the Avenal, California, crash and encourage manufacturers to accelerate development and prioritize deployment of advanced impaired driving prevention technology and to seek innovative ways to adapt existing technologies, such as driver monitoring systems, to combat alcohol-impaired driving. (H-22-24)

4.2 Previously Issued Recommendations Classified and Reiterated in This Report

The National Transportation Safety Board classifies and reiterates the following safety recommendations.

To the National Highway Traffic Safety Administration:

> Incentivize passenger vehicle manufacturers and consumers to adopt intelligent speed adaptation (ISA) systems by, for example, including ISA in the New Car Assessment Program. (H-17-24)

Safety Recommendation H-17-24 is classified "Open—Unacceptable Response" and reiterated in section 2.5.3.2 of this report.

> Develop and disseminate to appropriate state officials a common standard of practice for drug toxicology testing, including (1) the circumstances under which tests should be conducted, (2) a minimum set of drugs for which to test, and (3) cutoff values for reporting the results. (H-12-33)

Safety Recommendation H-12-33 is classified "Open—Unacceptable Response" and reiterated in section 2.6.1 of this report.

4.3 Previously Issued Recommendations Classified in this Report

As a result of its investigation, the National Transportation Safety Board classifies the following two safety recommendations:

To the National Highway Traffic Safety Administration:

> Work with the Automotive Coalition for Traffic Safety, Inc., to accelerate widespread implementation of Driver Alcohol Detection System for Safety (DADSS) technology by (1) defining usability testing that will guide driver interface design and (2) implementing a communication program that will direct driver education and promote public acceptance. (H-12-43)

To the Automotive Coalition for Traffic Safety, Inc.:

> Work with the National Highway Traffic Safety Administration to accelerate widespread implementation of Driver Alcohol Detection System for Safety (DADSS) technology by (1) defining usability testing that will guide driver interface design and (2) implementing a communication program that will direct driver education and promote public acceptance. (H-12-48)

Safety Recommendations H-12-43 and -48 are classified "Closed—Unacceptable Action" in section 2.4.3.2 of this report.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JENNIFER HOMENDY
Chair

MICHAEL GRAHAM
Member

BRUCE LANDSBERG
Vice Chairman

THOMAS CHAPMAN
Member

Report Date: August 22, 2022

Appendixes

Appendix A: Investigation

The National Transportation Safety Board (NTSB) was notified of this crash on January 2, 2021; however, an investigative team was not dispatched to the scene due to COVID-19 travel restrictions. From January through March 2021, the NTSB coordinated with investigators from the California Highway Patrol (CHP) Coalinga Area office and the CHP's Multidisciplinary Accident Investigation Team to collect perishable physical evidence and to document the condition of the vehicles and crash scene. On March 16, 2021, the NTSB completed a follow-up visit to the scene to inspect the highway environment and observe friction testing of the State Route 33 roadway surface.

The CHP was party to the investigation.

Appendix B: Consolidated Recommendation Information

Title 49 *United States Code* 1117(b) requires the following information on the recommendations in this report.

For each recommendation–

(1) a brief summary of the Board's collection and analysis of the specific accident investigation information most relevant to the recommendation;

(2) a description of the Board's use of external information, including studies, reports, and experts, other than the findings of a specific accident investigation, if any were used to inform or support the recommendation, including a brief summary of the specific safety benefits and other effects identified by each study, report, or expert; and

(3) a brief summary of any examples of actions taken by regulated entities before the publication of the safety recommendation, to the extent such actions are known to the Board, that were consistent with the recommendation.

To the National Highway Traffic Safety Administration:

H-22-22

Require that all new vehicles be equipped with passive vehicle-integrated alcohol impairment detection systems, advanced driver monitoring systems, or a combination thereof; the systems must be capable of preventing or limiting vehicle operation if driver impairment by alcohol is detected.

Information that addresses the requirements of 49 USC 11179(b), as applicable, can be found in section 2.4.3, Vehicle-Integrated Passive Alcohol Detection Technology. Information supporting (b)(1) can be found on pages 29–37; (b)(2) and (b)(3) are not applicable.

To the state of California:

H-22-23

Enact legislation that requires forensic toxicology laboratories to follow the standards recommended by the National Safety Council's Alcohol, Drugs, and Impairment Division; the legislation should include a provision requiring laboratories to update the testing protocol if additional federal guidance is provided.

Information that addresses the requirements of 49 USC 11179(b), as applicable, can be found in section 2.6, Need to Implement a Uniform Standard for Drug Toxicology Testing. Information supporting (b)(1) can be found on pages 42–45; (b)(2) and (b)(3) are not applicable.

To the Alliance for Automotive Innovation:

H-22-24

Inform your members of the Avenal, California, crash and encourage manufacturers to accelerate development and prioritize deployment of advanced impaired driving prevention technology and to seek innovative ways to adapt existing technologies, such as driver monitoring systems, to combat alcohol-impaired driving.

Information that addresses the requirements of 49 USC 11179(b), as applicable, can be found in section 2.4.3, Vehicle-Integrated Passive Alcohol Detection Technology. Information supporting (b)(1) can be found on pages 29–37; (b)(2) and (b)(3) are not applicable.

Appendix C: DADSS System Specifications

Table C-1. System specifications for passive alcohol detection technologies. (Source: Biondo, Zaouk, and Sundararajan 2017)

Criterion	Specifications
Speed	<325 ms sensor activation to decision / 400 ms sensor reset to decision
Sensing range	Detects BAC .01-.12
Durable	15-year/187,500-mile life
Reliability	<.34 defects per million
Precision at different ethanol levels	BAC (SE/SD) 0.020 (0.0010) 0.040 (0.0010) 0.060 (0.0007) 0.080 (0.0003) 0.120 (0.0010)
Accuracy in the presence of driver-introduced substances	Perfume, aftershave, tobacco smoke, mouthwash, disease-state halitosis containing sulfur or ketones
Accuracy in the presence of ambient-air substances	Acetaldehyde (0.08 mg/L), Acetone (0.25 mg/L), Carbon monoxide (0.10 mg/L), Diethyl ether (0.15 mg/L), Ethyl acetate (0.08 mg/L), N-Heptane (0.10 mg/L), N-Hexane (0.10 mg/L), Methane (0.15 mg/L), Methanol (0.05 mg/L), N-octane (0.10 mg/L), N-pentane (0.10 mg/L), 2-propanol (0.05 mg/L), Toluene (0.10 mg/L)
Accuracy in the presence of substances on driver's arm/hand	Perfume, aftershave, tobacco, antibacterial soap, lotion, hand cleaner, suntan lotion, vehicle fuel, paint, grease, dirt/soil, food
Driver convenience	Non-invasive
Security	Not susceptible to circumvention
Zero tolerance capability	Refer to SAE J3214_202101 for breath-based zero tolerance standards. Touch-based standards have not yet been developed
Vibration	ISO 16750-3, section 4.1.2.4 or section 4.1.2.7
Mechanical shock	ISO 16750-3, Section 4.2.2
Free fall	ISO 16750-3, Section 4.3
Tests - constant temperature	ISO 16750-4, Section 5.1
Temperature steps	ISO 16750-4, Section 5.2
Temperature cycling	ISO 16750-4, Section 5.3.1 (with 1000 cycles) and Section 5.3.2 (with 100 cycles)
Salt spray	ISO 16750-4, Section 5.5.1 (severity 5) and Section 5.5.2
Humid heat cyclic	ISO 16750-4, Section 5.7
Electromagnetic Compatibility (EMC)	IEC standards CISPR 25 and 61000-4-21 in addition to ISO standards 7637-2, 7637-3, 10605, 11452-2, and 11452-4 Radiated Emissions, Component Tests Bulk Current Injection, Component Tests Radiated Immunity, Component Tests Conducted Transient Emissions and Immunity, Component Tests Electrostatic Discharge (ESD), Component Tests
Electrical loads	ISO 16750-2
Protection against dust	ISO standard 20653 (code IP5KX) using ISO 12103- 1, A2 fine test dust
Protection against water	ISO standard 20653 (code IPX2)

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