

NATIONAL TRANSPORTATION SAFETY BOARD
Public Meeting of November 19, 2019
(Information subject to editing)

**Collision Between Vehicle Controlled by Developmental Automated Driving System and
Pedestrian**
Tempe, Arizona
March 18, 2018
HWY18MH010

This is a synopsis from the NTSB's report and does not include the Board's rationale for the conclusions, probable cause, and safety recommendations. NTSB staff is currently making final revisions to the report from which the attached conclusions and safety recommendations have been extracted. The final report and pertinent safety recommendation letters will be distributed to recommendation recipients as soon as possible. The attached information is subject to further review and editing to reflect changes adopted during the Board meeting.

Executive Summary

On March 18, 2018, at 9:58 p.m., an automated test vehicle, based on a modified 2017 Volvo XC90 sport utility vehicle (SUV), struck a female pedestrian walking across the northbound lanes of N. Mill Avenue in Tempe, Arizona. The SUV was operated by the Advanced Technologies Group of Uber Technologies, Inc., which had modified the vehicle with a proprietary developmental automated driving system (ADS). A female operator occupied the driver's seat of the SUV, which was being controlled by the ADS. The road was dry and was illuminated by street lighting.

The SUV was completing the second loop on an established test route that included part of northbound N. Mill Avenue. The vehicle had been operating about 19 minutes in autonomous mode—controlled by the ADS—when it approached the collision site in the right lane at a speed of 45 mph, as recorded by the ADS. About that time, the pedestrian began walking across N. Mill Avenue where there was no crosswalk, pushing a bicycle by her side.

The ADS detected the pedestrian 5.6 seconds before impact. Although the ADS continued to track the pedestrian until the crash, it never accurately classified her as a pedestrian or predicted her path. By the time the ADS determined that a collision was imminent, the situation exceeded the response specifications of the ADS braking system. The system design precluded activation of emergency braking for collision mitigation, relying instead on the operator's intervention to avoid a collision or mitigate an impact.

Video from the SUV's inward-facing camera shows that the operator was glancing away from the road for an extended period while the vehicle was approaching the pedestrian. Specifically, she was looking toward the bottom of the SUV's center console, where she had placed her cell phone at the start of the trip. The operator redirected her gaze to the road ahead about 1 second before impact. ADS data show that the operator began steering left 0.02 seconds before

striking the pedestrian, at a speed of 39 mph. The pedestrian died in the crash. The vehicle operator was not injured. Toxicological tests on the pedestrian's blood were positive for drugs that can impair perception and judgment.

The investigation identified the following safety issues:

- ***Uber Advanced Technologies Group's inadequate safety culture.*** At the time of the crash, the Uber Advanced Technologies Group had an inadequate safety culture, exhibited by a lack of risk assessment mechanisms, of oversight of vehicle operators, and of personnel with backgrounds in safety management. Since the crash, the company has made changes in organizational, operational, and technical areas. The report explores the deficiencies that led to the crash, the potential countermeasures, and the extent to which the postcrash changes made by the Uber Advanced Technologies Group affect the safe testing of ADSs.
- ***Need for safety risk management requirements for testing automated vehicles on public roads.*** Although the National Highway Traffic Safety Administration has published three iterations of an automated vehicles policy, that summary guidance does not provide a means of evaluating an ADS. The absence of safety regulations and detailed guidance has prompted some states to develop their own requirements for automated vehicle testing. The report explores the roles of federal agencies, industry, and individual states in supporting the development of automation and ensuring public safety during ADS testing.

Findings

1. None of the following were factors in the crash: (1) driver licensing, experience, or knowledge of the automated driving system operation; (2) vehicle operator substance impairment or fatigue; or (3) mechanical condition of the vehicle.
2. The emergency response to the crash was timely and adequate.
3. The pedestrian's unsafe behavior in crossing the street in front of the approaching vehicle at night and at a location without a crosswalk violated Arizona statutes and was possibly due to diminished perception and judgment resulting from drug use.
4. The Uber Advanced Technologies Group did not adequately manage the anticipated safety risk of its automated driving system's functional limitations, including the system's inability in this crash to correctly classify and predict the path of the pedestrian crossing the road midblock.
5. The aspect of the automated driving system's design that precluded braking in emergency situations only when a crash was unavoidable increased the safety risks associated with testing automated driving systems on public roads.
6. Because the Uber Advanced Technologies Group's automated driving system was developmental, with associated limitations and expectations of failure, the extent to which those limitations pose a safety risk depends on safety redundancies and

mitigation strategies designed to reduce the safety risk associated with testing automated driving systems on public roads.

7. The Uber Advanced Technologies Group's deactivation of the Volvo forward collision warning and automatic emergency braking systems without replacing their full capabilities removed a layer of safety redundancy and increased the risks associated with testing automated driving systems on public roads.
8. Postcrash changes by the Uber Advanced Technologies Group, such as making Volvo's forward collision warning and automatic emergency braking available during operation of the automated driving system (ADS), added a layer of safety redundancy that reduces the safety risks associated with testing ADSs on public roads.
9. Had the vehicle operator been attentive, she would likely have had sufficient time to detect and react to the crossing pedestrian to avoid the crash or mitigate the impact.
10. The vehicle operator's prolonged visual distraction, a typical effect of automation complacency, led to her failure to detect the pedestrian in time to avoid the collision.
11. The Uber Advanced Technologies Group did not adequately recognize the risk of automation complacency and develop effective countermeasures to control the risk of vehicle operator disengagement, which contributed to the crash.
12. Although the installation of a human-machine interface in the Uber Advanced Technologies Group test vehicles reduced the complexity of the automation-monitoring task, the decision to remove the second vehicle operator increased the task demands on the sole operator and also reduced the safety redundancies that would have minimized the risks associated with testing automated driving systems on public roads.
13. Although the Uber Advanced Technologies Group had the means to retroactively monitor the behavior of vehicle operators and their adherence to operational procedures, it rarely did so; and the detrimental effect of the company's ineffective oversight was exacerbated by its decision to remove the second vehicle operator during testing of the automated driving system.
14. The Uber Advanced Technologies Group's postcrash inclusion of a second vehicle operator during testing of the automated driving system, along with real-time monitoring of operator attentiveness, begins to address the oversight deficiencies that contributed to the crash.
15. The Uber Advanced Technologies Group's inadequate safety culture created conditions—including inadequate oversight of vehicle operators—that contributed to the circumstances of the crash and specifically to the vehicle operator's extended distraction during the crash trip.
16. The Uber Advanced Technologies Group's plan for implementing a safety management system, as well as postcrash changes in the company's oversight of vehicle operators, begins to address the deficiencies in safety risk management that contributed to the crash.
17. Mandatory submission of safety self-assessment reports—which are currently voluntary—and their evaluation by the National Highway Traffic Safety

Administration would provide a uniform, minimal level of assessment that could aid states with legislation pertaining to the testing of automated vehicles.

18. Arizona's lack of a safety-focused application-approval process for automated driving system (ADS) testing at the time of the crash, and its inaction in developing such a process since the crash, demonstrate the state's shortcomings in improving the safety of ADS testing and safeguarding the public.
19. Considering the lack of federal safety standards and assessment protocols for automated driving systems, as well as the National Highway Traffic Safety Administration's inadequate safety self-assessment process, states that have no, or only minimal, requirements related to automated vehicle testing can improve the safety of such testing by implementing a thorough application and review process before granting testing permits.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the crash in Tempe, Arizona, was the failure of the vehicle operator to monitor the driving environment and the operation of the automated driving system because she was visually distracted throughout the trip by her personal cell phone. Contributing to the crash were the Uber Advanced Technologies Group's (1) inadequate safety risk assessment procedures, (2) ineffective oversight of vehicle operators, and (3) lack of adequate mechanisms for addressing operators' automation complacency—all a consequence of its inadequate safety culture. Further factors contributing to the crash were (1) the impaired pedestrian's crossing of N. Mill Avenue outside a crosswalk, and (2) the Arizona Department of Transportation's insufficient oversight of automated vehicle testing.

Recommendations

To the National Highway Traffic Safety Administration:

1. Require entities who are testing or who intend to test a developmental automated driving system on public roads to submit a safety self-assessment report to your agency.
2. Establish a process for the ongoing evaluation of the safety self-assessment reports as required in Safety Recommendation 1 and determine whether the plans include appropriate safeguards for testing a developmental automated driving system on public roads, including adequate monitoring of vehicle operator engagement, if applicable.

To the state of Arizona:

3. Require developers to submit an application for testing automated driving system (ADS)-equipped vehicles that, at a minimum, details a plan to manage the risk associated with crashes and operator inattentiveness and establishes countermeasures to prevent crashes or mitigate crash severity within the ADS testing parameters.

4. Establish a task group of experts to evaluate applications for testing vehicles equipped with automated driving systems, as described in Safety Recommendation 3, before granting a testing permit.

To the American Association of Motor Vehicle Administrators:

5. Inform the states about the circumstances of the Tempe crash and encourage them to (1) require developers to submit an application for testing automated driving system (ADS)-equipped vehicles that, at a minimum, details a plan to manage the risk associated with crashes and operator inattentiveness and establishes countermeasures to prevent crashes or mitigate crash severity within the ADS testing parameters, and (2) establish a task group of experts to evaluate the application before granting a testing permit.

To the Uber Technologies, Inc., Advanced Technologies Group:

6. Complete the implementation of a safety management system for automated driving system testing that, at a minimum, includes safety policy, safety risk management, safety assurance, and safety promotion.