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Caltrans Division of Research, Innovation and System Information

Research Results

Caltrans Autonomous Vehicles Industry Survey of Transportation Infrastructure Needs

A survey that identified what transportation infrastructure improvements or modifications were needed to improve AV performance.

WHAT WAS THE NEED?

As Automated Vehicles (AV) continued to advance from research towards deployment, many optimists in the AV industry predicted that fully-automated vehicles would be introduced to public roadways by 2025 or even earlier. However, there were various open questions and issues that needed research, planning, and resolution at State and local transportation agencies to enable successful broad deployment of AV. A key question among these was "What transportation infrastructure improvements or modifications were needed to improve AV performance?"

A number of AV companies had reported that certain aspects of transportation infrastructure (e.g. poor pavement markings, poor sign visibility, unexpected lane closures, etc.) were impacting the reliability of AV systems being tested on public roads. At the same time, California was looking to modify/improve roadways so that they could accommodate the vehicles of the future. However, currently there was very limited dialog occurring between the AV industry and infrastructure owners and operators to ensure that AV needs were being factored into infrastructure design plans.

WHAT WAS OUR GOAL?

The end goal was to find out what infrastructure modifications were needed to safely operate AV on the state highway system.

WHAT DID WE DO?

The research team set up meaningful communication between the government agencies and the AV industry. A survey was designed and conducted by inviting selected AV industry players.

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The purpose of the interviews was to have in-depth dialog with the AV companies in a private, one-on-one setting on what modifications or improvements they would most desire to improve the performance and reliability of automated vehicles.

The topics discussed ranged from basic infrastructure features such as striping and signage to more advanced topics such as availability of real-time information on road conditions, digital mapping, vehicle-to-roadside communication infrastructure, and use of dedicated facilities for AV operations. The findings of the interviews have been summarized in a report. The final report was be shared with Caltrans and other interested departments like Department of Motor Vehicles and California Highway Patrol etc.

WHAT WAS THE OUTCOME?

The survey was complete, and a final presentation was completed on March 10, 2021.

In total, 20 companies responded to the online survey. They were from different sectors within the AV industry, including the autonomous car start-up companies, with companies focusing on both passenger vehicles and low-speed shuttle buses; the autonomous truck start-up companies; the autonomous technology provider start-up companies, with companies working on both autonomous driving hardware and software; traditional automotive car manufacturers; and traditional automotive parts manufacturers. The composition indicates that the survey respondents represented the important players in the AV industry well.

The responded companies are internationally based, with most of them US companies, some others from either Europe or Asia. In the follow-up interview, eight out of the 20 survey respondents participated, with six of them carried out in the zoom-meeting format, and the remaining two provided written feedback.

A list of survey question and the results are listed below:

- The most important roadway characteristics or features that have the potential to benefit the automated driving system (ADS) are (1) digital map and signage; (2) lane markings; (3) work zone and incident information; (4) Vehicle to X (infrastructure, other vehicles, network, etc.) Communication, V2X data; (5) traffic signals; (6) general signage; and (7) lighting.
- Regarding specifications or standards associated with the roadway characteristics, respondents provided some information related to quantifiable specifications for high definition (HD) map, V2X data frequency, and lighting. Other than that, not much information regarding standards or specifications for the roadway characteristics since they are mostly not available yet.
- To the question of "Do you see the need for different infrastructure maintenance requirements when considering the use of ADS rather than human-driven vehicles?" most respondents agreed that the infrastructure would need to be monitored and maintained more stringently if state DOTs want to help improve ADS capability on the roadways. AV companies are interested in obtaining information regarding when road segments are non-compliant with the prevalent or commonly adopted infrastructure standards.
- To the question of "What particular issues (if any) exist for ADS to interpret certain physical infrastructure elements, such as lane marking, traffic signals, HOV/bike lanes, and signs?" the most mentioned physical infrastructure issues were associated with lane markings, signage, traffic signals, and others such as work zones, flashing lights, and retroreflectors.
- Regarding digital features of infrastructure and transportation operations, the following items were the most expected digital infrastructures data to help accelerate ADS deployment, in the order of their selection frequency: (1) work zone and road closure, (2) traffic signal phase and timing, (3) traffic congestion or real-time traffic information, (4) general V2X, and (5) HD maps.

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- Regarding preferred channels for receiving V2X data, the majority respondents thought as long as the information is available it can be utilized in various ways. Therefore, it was recommended that the industry should reach an agreement on what V2X technology to use. When it comes to a safety-critical input to the ADS, it is strongly desirable to have more than one communication path. So V2X plus cellular connection would be good for safety-critical inputs.

- Regarding the support from public agencies, most respondents shared the expectation that the state should consider the V2X policies, such as equipping the traffic signals with V2X information. They recommended having a policy for better maintenance of the infrastructure's physical elements, such as lane markings and road signage, and also a policy for the maintenance of specific operational routes.

- As for the timeline of deployment, all respondents share the notion that AV development is an incremental process. Most of the respondents believe in the mode of shared mobility for public transportation and goods movements in predefined environments. That way, the fleet and service providers will continue to own the vehicles. Regarding ownership of L4 or L5, it will be driven by the acceptance of the L4 or L5 mobility services.

- Most respondents agree that having a venue for engagement between the governmental agencies and the AV industry, and having standards or best-practice guidelines related to infrastructure are very important for AV research and development. The use of consortiums to improve industry engagement is encouraged. There was a consensus that there should be more government and industry collaborations happening where safety is concerned (e.g., sharing data).

- Regarding data sharing, from the AV companies' perspective, the AV testing data is mainly focused on the performance of automated driving systems, but not the roadway features or measurements. There are also various concerns regarding proprietary information embedded in the data, potential liability issues, or the amount of labor work needed for annotating the data before sharing.

WHAT IS THE BENEFIT?

Caltrans will find out recommendations from key AV industry players to be considered as related to making changes or improvements to the state highway infrastructure to enhance AV operations. The recommendations were be grouped into high, medium and low priority. These recommendations will help Caltrans in future planning and policy formation on infrastructure improvements relating to AV.