SENIOR DRIVERS & AUTOMATED VEHICLES: KNOWLEDGE, ATTITUDES & PRACTICES

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Standing Committee on Transport, Infrastructure and Communities
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Traffic Injury Research Foundation

The mission of the Traffic Injury Research Foundation (TIRF) is to reduce traffic-related deaths and injuries. TIRF is an independent, charitable road safety research institute. Since its inception in 1964, TIRF has become internationally recognized for its accomplishments in identifying the causes of road crashes and developing program and policies to address them effectively.

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INTRODUCTION

Canadians over the age of 65 currently represent one in seven Canadians. In the next two decades, the population of seniors will grow to more than 10 million and they will account for one in four Canadians (Statistics Canada 2015). As one of the largest age cohorts, older adults will be a significant segment of the driving population. Well-documented effects of age-related declines in perceptual, cognitive, and motor skills on driving ability (Wood et al. 2008; Klavora & Heslegrave 2002), and the over-representation of drivers older than 80 years in crash statistics due to their frailty, present a major road safety challenge that requires attention (Evans, Gerrish, & Taheri 1998; Li, Braver, & Chen 2003).

The ability for seniors to continue to drive as they age is integral to their health. As such, it is imperative that older drivers are protected on the road, and able to continue to drive safely as they age. Advanced safety features and automated vehicles offer great potential to improve road safety and the mobility of older drivers. However, research from the Traffic Injury Research Foundation (TIRF) has suggested that older drivers are less confident in these technologies, are less familiar with them, and are least likely to rely on them to improve their safety on the road (Robertson et al. 2016, 2017). Similarly, a recent study regarding acceptance and attitudes in relation to automated vehicles revealed that a larger percentage of older drivers were sceptical about automated vehicles (Nielsen & Haustein 2018).

The Traffic Injury Research Foundation (TIRF), with funding from the Toyota Canada Foundation, conducted an national, representative, online survey of 2,662 Canadian drivers ranging in age from 16 to 93 years. These data were further augmented with qualitative data from focus groups involving 38 drivers aged 65 years and older. The purpose of this study was to explore the knowledge, attitudes and practices of aging Canadian drivers regarding limited self-driving vehicles (LSDVs), and how their knowledge and beliefs about LSDVs affects the likelihood they will rely on this technology to improve their safety and increase their mobility.

The survey results are presented below with a special emphasis on older drivers followed by the results from the focus groups. Collectively, results provide insight into strategies to encourage the early adoption of automated vehicles by older drivers and facilitate a safer transition towards automated vehicles that is lead by a cohort of safety-conscious drivers.

METHODS

National survey

A national survey was conducted to explore the knowledge, attitudes, and practices of Canadians in relation to LSDVs. Priority areas that were explored included acceptance of vehicle technology regarding perceived ease of use and perceived usefulness, trust in automation, and behavioural adaptation by drivers in response to LSDVs. A detailed description of the data collection, analyses and results can be found in the report titled "Senior drivers and automated vehicles: Knowledge, attitudes and practices" (Robertson et al. 2018) available at http://tirf.ca/TIRFCAD18JJ.

Data. A total of 2,662 Canadians completed the survey in April 2016 which was fielded by Nielson Opinion Quest. The sample was representative of Canada, and used a disproportional stratified (by region) random sample. All respondents possessed a valid driver's licence and had driven within the past 30 days. The age of respondents ranged from 16 to 93 years of age, with a mean age of 53. Slightly less than half (47%) of respondents were male and slightly more than half (53%) were female.

Analyses. The data were analyzed to understand perceptions of, trust in, and behavioural adaptation to LSDVs and their possible association with the intention to use and adopt this technology. Structural equation modelling (SEM) was used, which is an extension of multiple regression analysis that allows more than one dependent variable at a time and allows variables to be dependent with respect to some variables and independent with respect to others. (Rabe-Hesketh et al. 2004; Skrondal et al. 2004) Furthermore, SEM enables the use of latent variables, which are underlying factors that are not directly observable (i.e., "unseen constructs") but can be associated with observable, measured variables. Ultimately SEM helps to determine if a set of variables fits well with a particular *a priori* theoretical model[1].

Age (measured in years as a continuous variable) and sex of respondents (1: male, 2: female), although not represented in the figures, were included in both models as exogenous variables (i.e., determined outside the model, not affected by any other variable).

Focus groups

Focus groups were conducted with 38 senior drivers to explore their level of knowledge about LSDV technology, their attitudes towards LSDVs with respect to benefits and concerns associated with the technology, and their practices and intentions to use LSDVs. Strategies to deliver education and training to older drivers about this new technology were also discussed to gain insight into the most effective ways to reach the population of senior drivers and increase their knowledge about and awareness of LSDV technology.

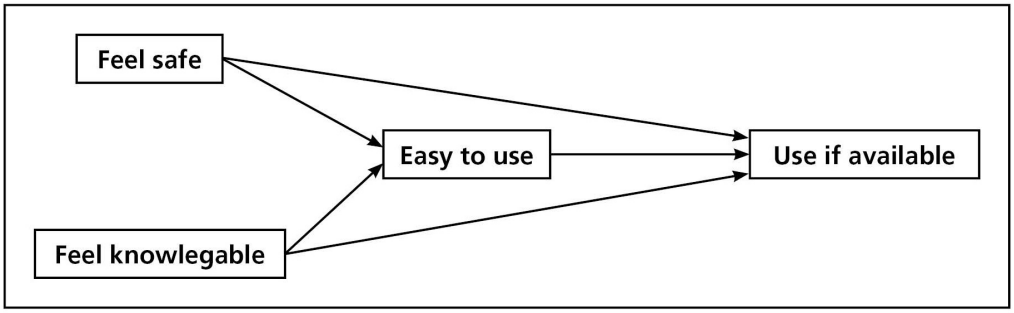
[1] All quantitative data analyses were conducted using Stata/MP 14.1 for windows 64-bit x86-64 (StataCorp, 2015). Responses were weighted by sex, age, and population to account for variations across Canada. All analyses corrected results for design effects of our sample (i.e., stratification and weighting) using Stata's svy-procedures.

RESULTS

National survey

Results. First, a simple model (Figure 1) was tested that studies the relationship between respondents' responses knowledge, safety, and confidence in using LSDVs and their intention to adopt the technology.

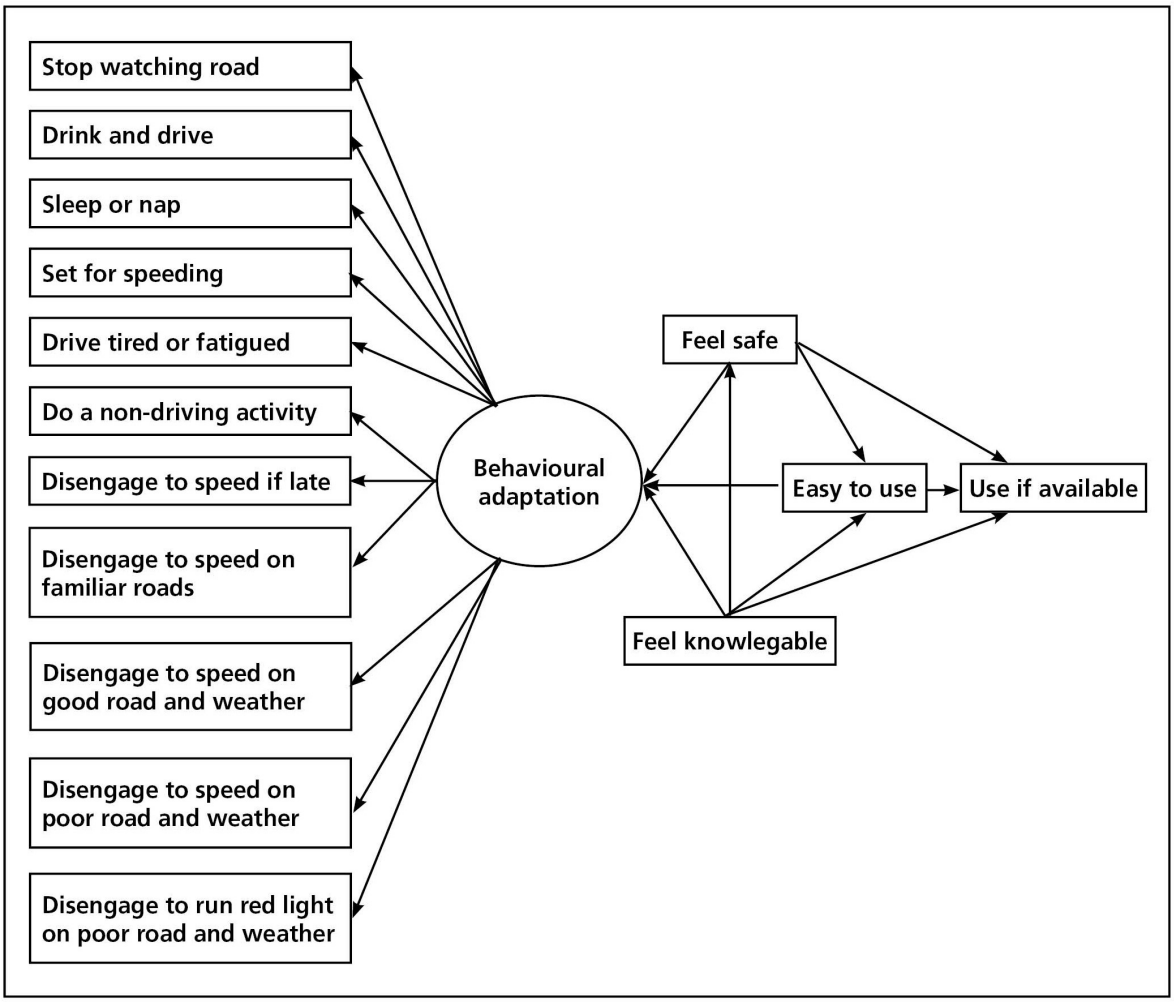
Figure 1: Hypothesized SEM on the relationship between feeling safe, knowledgeable and confident about using a LSDV and the intention to use it



Results from the first model showed that the model had a very good fit (SRMR <0.05; Li-tze and Peter, 2009) and all hypothesized effects were significant except for age. The results confirmed the hypothesis that feelings of knowledge and safety about LSDVs were positively related to perceived ease of use and adoption of the technology. In other words, drivers that feel more knowledgeable about and safer with LSDVs are more likely to use them. Female drivers were less agreeable with the statements about knowledge, safety, perceived ease of use and adoption of technology than male drivers. This means that females felt less knowledgeable about LSDVs and less safe than males, and hence were less likely to state they would use a LSDV compared to males.

A second, more complex model (Figure 2) extended the first one by including other observable variables (e.g., drink and drive, sleep or nap, drive tired or fatigued) as indicators of the unobserved latent variable "behavioral adaptation." These observable variables were measured based on responses from respondents about their willingness to modify their driving behaviours in negative ways that would increase their risk and undermine safety while using LSDVs. The model also allowed for the testing of a hypothesis regarding the relationship between behavioural adaptation and feelings of knowledge, safety, confidence, and intention to use the technology.

Figure 2: Extended hypothesized SEM including behavioural adaptation variables



Results from the extended model, which included the construct "behavioural adaptation", showed that the model had an adequate fit (SRMR<0.08), and confirmed previous results from the simple model. Notably, it showed that feelings of knowledge about and safety with LSDVs were positively related to each of the risky behavioural adaptions included in the model. These results suggest that drivers who feel safer and more knowledgeable about LSDVs were more likely to admit that they would engage in risky driving behaviours. These drivers were also more likely to declare they will use LSDVs. Conversely, older drivers and females were, on average, less likely to agree and report they would be less likely to engage in risky behaviours.

In addition, drivers aged 50 years and older were also less agreeable about LSDVs being easy to use in comparison to younger drivers. Furthermore, drivers aged 70 years or older were less agreeable about feeling safe using LSDVs.

Summary. The results of these analyses confirmed the hypothesis that feelings of knowledge about and safety with LSDVs are positively related to perceived ease of use and adoption of

technology. In other words, drivers that feel more safe using LSDVs and more knowledgeable about LSDVs are more likely to believe that LSDVs will be easy to use, and are more likely to use them.

Of concern, older drivers were less likely to agree that LSDVs would be easy to use or agree that they would feel safe using them. Similarly, female drivers were less agreeable with statements about knowledge, safety, and perceived ease of use than male drivers, and were less likely to declare that they will use LSDVs than males.

These results are concerning because older drivers have the most to gain from automated vehicles in terms of extending their driving career and increasing their mobility. More importantly, they represent one of the safest cohorts of drivers who are least likely to engage in risky driving behaviours. However, at present, they are least likely to use LSDVs. There is a clear opportunity to deliver targeted education to aging drivers to overcome the lack of knowledge among this population and demonstrate the ease of use of this technology. Such initiatives can thereby increase perceptions of safety and the likelihood that older drivers as well as women will become earlier adopters of LSDVs, in sharp contrast to the high-risk population of younger, male drivers that are currently poised to be the early adopters of this technology.

Focus groups

Results from the focus groups are summarized below according to the following key areas: knowledge, attitudes, practices, and education and training.

Knowledge. Analyses revealed that senior drivers were not very familiar with LSDV technology, and had a limited understanding of automated vehicles generally, although many of them were familiar with specific examples of some features of LSDV technology. The majority of participants had questions about how the technology works and when it would be publicly available. While most of them were aware that their knowledge of LSDVs was limited, they expressed interest in learning more about LSDVs.

Attitudes. Senior drivers perceived safety to be the greatest benefit of LSDVs. They mentioned that LSDVs could help improve personal safety for them as drivers, as well as road safety generally. Senior drivers also acknowledged that LSDVs could help increase confidence in their driving skills as they age, and LSDVs would enable them to handle more challenging situations on the road with more confidence as opposed to avoiding them.

Concerns highlighted during the focus groups included their over-reliance on self-driving technology, and how this could eventually degrade their driving skills. They also expressed that relying on self-driving features could tempt them to be less attentive behind the wheel, and contribute to themselves as well as other drivers engaging in risky behaviors. Significant concern was also conveyed regarding the learning curve for senior drivers, and that it might be somewhat overwhelming to learn to use LSDVs. It was generally agreed that older drivers would require training and practice with LSDV technology in a classroom or on a simulator before feeling comfortable enough to drive a vehicle. Other concerns included the higher cost that could be associated with the purchase of this new technology, as well as the additional costs resulting from higher insurance premiums, and more expensive maintenance and repairs.

Practices. More than three-quarters of participants reported that they were willing to use an LSDV if it were available today, and once they had observed others using the technology safely and without incident. To build their trust in LSDVs, the majority of senior drivers indicated that they would need to gain more experience with the technology, and better understand the reliability of the self-driving features and the capability of these technologies under various conditions. Participants shared that they would most likely use the self-driving features of LSDVs for long distance drives, or in stressful driving conditions. However, senior drivers highlighted the primary barriers to adopting this technology which included the anticipated learning curve associated with driving LSDVs, and the significant cost associated with purchasing this new technology. These barriers were particularly notable for this age cohort since older drivers generally drive fewer kilometres and less frequently as they age.

Education and training

The need for education about LSDVs was explored during the focus group discussions to gain insight into educational topics of interest and the most effective ways to reach the population of senior drivers to improve their knowledge and awareness of this technology. The following section summarizes these findings according to the key topics of education that are of the greatest interest, the types of learning environments preferred, as well as the format and duration of educational strategies. Potential delivery mechanisms for this education were also considered.

Topics of education

There was generally a high level of consensus among focus group participants regarding important topics that should be included in any educational strategy. Each of these topics is described briefly below.

- **Safety:** Participants reported that information about ways that LSDVs would protect them in the event of a collision was a priority. This included knowledge of more traditional metrics such as safety scores and crashworthiness ratings of LSDVs which are typically used to rank vehicle safety. Participants also wanted to learn about other important safety metrics such as resistance to hacking and how these vehicles would respond in the event of technology failure.
- **Performance:** Participants were interested in learning about the various functions and features of LSDVs and how these vehicles would perform under various conditions such as bad weather or heavy traffic. The issue of the takeover prompt was also a source of great interest. More specifically, participants indicated they wanted to know under what conditions self-driving features would be able to function, as well as the types of situations where drivers would likely be required to take over control of the vehicle. They also wanted to receive more detailed information regarding the takeover process, and how much time they would have to resume control of the vehicle when prompted to do so. Other priority topics related to the performance of the technology included the role and capacity of sensors to detect objects, and the programmable specifications of the technology.

Learning environment

The types of learning environment most preferred by participants were variable and these findings reflect important differences in learning styles that are consistent with research.

- **Practical learning:** Participants expressed that it would be most beneficial to learn how to use LSDVs in a practical setting that involved hands-on experience with driving LSDVs and this was a strong preference.
- **Classroom learning:** Many participants recognized the value of receiving education about LSDVs in a classroom environment so that drivers could acquire the knowledge base necessary to understand how LSDVs function. They reported that such an approach would provide them with materials that they could refer to as they gained hands-on experience.
- **Online learning:** Participants thought that education about LSDVs could be offered in an online environment. In particular, this strategy would allow seniors to learn at their own pace in an environment that was free of judgment of their skills and abilities in relation to those of others.

Educational format

Participants indicated distinct preferences regarding options to gain experience using these vehicles. These differences may be related, in part, to differences in the current comfort level of participants with driving. For example, participants that were more comfortable learning on a closed course were perhaps more confident in their current driving ability, whereas those who were more comfortable learning on a simulator, or using videos may have been somewhat less confident.

- **Driving simulator:** Participants believed that the safest format to learn about LSDVs was a driving simulator. They indicated that a simulator would give them the opportunity to become accustomed to the responsiveness of LSDVs, manipulate the controls, and visualize the additional information that may be presented on the dashboard of LSDVs. They also agreed that a simulator would allow senior drivers to practice the takeover in a variety of situations (weather, emergency, road hazard) and become comfortable taking over control from the self-driving mode when prompted.
- **On-road driving:** Participants stated that driving LSDVs on a closed circuit course would be the most effective way to learn about this technology. They suggested that they could learn about how LSDVs work and respond to a variety of situations with the help of an instructor. Although they acknowledged the greater risk associated with a hands-on learning environment, they believed that this would be the most realistic and could allow them a chance to ask questions as they learn, and gain experience in a safe environment before driving on public roads.
- **Text or video-based resources:** Participants noted that receiving educational materials summarizing the key areas of information would also be valuable, although they also acknowledged that material would have to be brief enough to ensure drivers would read it. They added that it was important for this information to be provided in an accessible language, and to be presented in a user-friendly format.

Duration of education

There were some variations in the amount of time that focus group participants were willing to invest in learning to use LSDVs which seemed to be a function of personal preferences, and perhaps their familiarity and comfort level associated with new technologies.

- **Single session:** Approximately half of participants expressed that they would like to learn about LSDVs during a full-day session, or two half-day sessions. Most of them believed that this would be sufficient time to learn how to use LSDVs.
- **Multi-module course:** The remaining half of participants indicated that they would like to learn about LSDVs in an incremental fashion. They agreed that this approach would give them the opportunity to learn about LSDVs without being overwhelmed and would allow them to gain experience as well as ask questions as they arose.

Source of education

- **Educational institutions:** Most participants agreed that education about LSDVs should be offered as part of lifelong learning programs that are available to seniors through colleges or universities. Many participants were already enrolled in these types of lifelong learning initiatives at their local college, and they believed that this type of environment would be ideal to reach the senior driving population since participation in these initiatives is generally high and they are most comfortable in classrooms with other seniors.
- **Community groups:** Similarly, participants expressed great interest in receiving education about LSDVs from local community groups (Ottawa Council on Aging, 55 alive, service clubs). Many participants were already involved in similar community groups and believed that education offered from local groups would reach a significant proportion of the senior population.
- **Driving schools:** Some participants believed that the best mechanism to educate them about LSDVs would be local driving schools. Additionally, they believed that there might be a different class of licence for drivers of LSDVs, and thus the education and assessment would be regulated by the government as a pre-requisite to owning LSDVs. They suggested that education about LSDVs would be offered by driving schools, and the assessment would be conducted by the provincial licensing bureau, similar to the existing licensing structure.
- **Dealerships:** Fewer participants indicated that it was the duty of dealerships to deliver more intensive education to consumers about LSDVs at the point of purchase. While there was consensus that some learning should take place during the buying experience or immediately following a purchase, there was also concern about a perceived conflict of interest, and the level of knowledge about features that sales staff may possess. It was also noted that sales staff may not have the time or availability to deliver the level of education that older drivers might need. In addition, some participants suggested that seniors may be more receptive to education from independent entities as opposed to dealers.

Recommendations

- **Create educational opportunities about LSDVs targeted towards aging drivers.** Results from the combined analysis of the national survey and focus group results suggest that their level of knowledge about LSDVs is directly related to the likelihood that they will adopt the technology. Educational strategies that accommodate the needs of seniors and their comfort in using new technologies are necessary to help them manage a significant learning curve. Such educational opportunities can increase their receptivity to adopting LSDV technology and ultimately enable seniors to reap the greatest benefits from LSDVs.
- **Focus education on the safety and performance of LSDVs as the trajectory of the technology becomes clearer.** The topics of greatest interest to senior drivers were the safety and performance of LSDVs. They wanted to know how LSDVs would help keep them safe in hazardous road conditions, and how LSDVs would help to them avoid collisions. In addition, they wanted information about the crashworthiness of these vehicles, the functionality of the technology, and the programmable specifications of LSDVs. Education focused on these topics is essential to ensuring that senior drivers can make informed decisions about using LSDVs to enhance their safety and mobility on the road.
- **Emphasize privacy and cyber security safeguards.** Older drivers expressed concerns about the safety and protection of their personal information if their vehicle was hacked. They were particularly concerned that LSDV technology could be susceptible to failure in the event of hacking. They stated that this could create potential opportunities for terrorist attacks or hackers looking to "prank" automotive companies and were concerned the safety of their personal information or their safety on the road could be jeopardized. As such, it is essential education about LSDVs specifically addresses privacy and cyber security safeguards, especially with older consumers in mind.
- **Tailor delivery strategies to meet the needs of aging drivers.** Education and training opportunities should be made available in different formats for older drivers. Results from the focus groups suggest that older drivers would strongly prefer to learn how to use LSDVs in a practical setting that involved hands-on experience, and that it would be most important for them to understand the functions of an LSDV and how the technology would respond in a potentially hazardous situation.
- **Ensure available infrastructure for practical learning.** Older drivers were most interested to learn about LSDVs in a practical setting, in an educational format such as a driving simulator or closed-circuit course. Partnerships and adequate funding is needed to support educational institutions such as community colleges, senior organizations or driving schools that are best-suited to reach older drivers. Notably, these entities are easily accessed by seniors and possess some of the necessary infrastructure to help older drivers learn how to use LSDV technology in a safe and controlled setting.

CONCLUSIONS

In conclusion, there was significant evidence that drivers in older age cohorts were very interested in learning about semi-autonomous vehicle technology. They were also quite receptive to using it if certain conditions are met. To this end, it is important that the increased safety of these vehicles is proven, that costs of vehicles, insurance and repairs are affordable, and that key questions are answered regarding how and under what conditions the technology works best.

In addition, this research revealed that older drivers recognize the potential of LSDV technology to increase their safety on the road and instill greater confidence in their ability to drive under challenging conditions that are typically avoided. Of greater importance, this technology can enhance mobility among older drivers and help them to safely prolong driving and mitigate errors that are associated with age-related factors. As such, this cohort of drivers was very receptive to strategies and tools to help them learn to use LSDVs in ways that maximize safety benefits. There was widespread recognition that increased knowledge of LSDVs gained through education and training can help senior drivers to reap the greatest benefits from this technology.

Perhaps most notably, the widespread and early adoption of LSDVs by aging drivers can help to demonstrate the true safety potential of LSDVs. Older drivers generally have a low crash risk due to their accumulated years of driving experience and exposure to all types of road environments and conditions. This is in sharp contrast to younger drivers, and those who drive longer distances who are most likely to be early adopters of LSDVs, but whom also often represent the population of drivers involved in collisions.

In other words, the population of older drivers may be more sensitive to the inherent risks and limitations associated with semi-automated vehicles, and thereby best-suited to test them in the real world. Their experiences using semi-automated vehicles can be insightful regarding optimal strategies and conditions that are needed to safely integrate automated vehicles into the existing vehicle fleet consisting of – almost exclusively – traditional vehicles. Of equal importance, their ability to adapt to a new vehicle and road environment, as some of the safest drivers on the road, can help to set standards regarding the level of education and skills that drivers of all ages must possess before using semi-automated vehicles.

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