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User awareness, users and societal acceptance and ethics

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Summary

There are numerous predictions as to when the first fully automated cars will populate Europe's roads, ranging typically from 2025 to 2030. Automation is expected to enhance road safety and personal mobility efficiency, improving traffic flow and mainstreaming eco-driving. It is further expected to support the optimisation of infrastructure use and increase productivity by allowing drivers to perform other tasks.

Potential benefits and challenges are closely linked to the levels of driving automation considered. The standard[1] developed by the Society of Automotive Engineers (SAE) details five levels of automation for on-road vehicles. Automated road transport systems involving vehicles automation beyond SAE level 3[2] can significantly change the current transport systems as we know them today, impact their efficiency, safety, sustainability etc.

Today's vehicles increasingly support drivers via warning and other systems, some of which even take over specific driving tasks. The rise in driver assistance, vehicle connectivity and deployment of cooperative Intelligent Transport Systems paves the way for increased vehicle automation. Partially automated systems are available today, which steers media interest and public discussions.

This thematic interest group brings the user's perspective into the current debate on increased automated driving trends. It has been set-up within the CARTRE project not to address technical aspects, regulatory needs or testing outcomes. It focused on the acceptance of automation and automated road transport by the users and society and on the needs for driver training.

The Connected and Automated Driving (CAD) system can only perform according to the specifications, if it is used appropriately. For road automation to achieve the expected positive impacts on safety and efficiency, user acceptance is the key. At this stage, user acceptance poses a challenge with over half (56%) of survey respondents indicating that they "would not trust manufacturers and government assurance that driverless cars were safe"[3]. Opinions are split as to whether driverless cars would become as safe as human drivers with 38% of respondents agreeing and 37% disagreeing.

[1] http://standards.sae.org/j3016_201401/ Standard J3016
[2] https://www.sae.org/misc/pdfs/automated_driving.pdf
[3] AA Populus poll based on 21,202 members answers (2012).

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This report outlines eight main challenges linked to the deployment of automated functionalities, which need to be addressed from a users' perspective for them to reap the full benefit of the rising technology.

Scope

By defining the scope of the interest group, the following definitions have been accepted:

- *Users* are understood in its wide definition: road users, as "anyone who uses the road" and will include drivers, riders, passengers, cyclists, pedestrians, etc.
- *Acceptability* is the prospective judgement of measures to be introduced in the future. It is about making a system accepted at a maximum level by the greatest numbers of people, as a society, without practical experience of the system.
- *Acceptance* is the degree to which an individual intends to use a system and incorporates the system in his/her driving. Acceptance includes experiences and use of the system. For improving user acceptance, it is essential to understand the importance of a user-centred view, as it is the user who makes the decision to use or not to use a system.
- *Utility is th*e degree to which CAD system fulfils the purpose of the user. So far, there is little discussion about this.
- *Satisfaction* is the degree to which the user enjoys using the system.

This interest group has addressed the following issues:

User awareness: awareness of the situation that automated driving system is aimed at tackling. Awareness of opportunity: automation provides with a new opportunity of mobility.

User acceptance:

- In terms of use: acceptability of automated driving systems, willingness to have and to use, actual use.
- In terms of safety: liability; responsibility; level of risk acceptance (which level of risk is acceptable for the user).
- In terms of freedom and privacy: data protection and cybersecurity.

User and societal requirements and expectations: minimum level needed for the user acceptance and services expected by users.

Ethical questions - from a user point of view only:

- Hypothetical questions: What about one of the vehicle actions has a bad consequence. How will the system choose?
- Fundamental questions: Can minors travel alone in my automated vehicle?
  What about people that will not be able to afford AVs (due to high price etc.) leading to questions related to social equity?

Societal acceptance: how the society (administration, operators, infrastructure providers) is willing to impose automation. The first step of societal acceptance is to create a legal framework.

Driver training:

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- As a mean to an end: training to increase acceptance and awareness. Acceptance come from a practical use of the technology.
- For a proper use of automated driving systems: ensure safe use of automated driving functionalities in context they are meant to be used and, thus, safe vehicle handling with reduced driver attention.
- Driver licenses should be issued according to the levels of automation.

Position

The thematic interest group has identified eight main challenges that it believes in need to be addressed from a users' perspective in the wake of connected automated driving.

User centric approach | A preliminary challenge consists in defining the users and their concerns. There should be a strong focus on the acceptance by individual (private) drivers as well as on professional users (fleet owners, taxi companies, road authorities, etc.). Automated functionalities need to be designed with the user in mind, with user-friendly Human Machine Interfaces and sufficient lead time for drivers to resume driving if necessary. For many people, a choice of car is also an expression of their personality and life-style. There should be more research done on how such personality will be affected by automated vehicles.

User awareness | Secondly, and relatedly, awareness is a key challenge to acceptance. User acceptance can only be investigated if much more information about automation developments is given to the public, and awareness campaigns should accompany the progressive deployment of automation functionalities. Also, hands-on experience and social discussion of automation will raise user awareness. However, current models of user acceptance of new technologies are not suitable for acceptance of road automation.

User trust | When it is assumed that road users are fully aware of automated driving possibilities of today, the biggest challenge for automated driving is to be trusted. It is widely recognised that road safety and liability are key factors, and that automated cars will have to be much safer than regular ones; still, users may not accept of even reject road automation. It has been also considered that the acceptance level can be different amongst social groups according to cultural, age and generational differences, and that user acceptance is closely linked to political goals from both local and national authorities.

Data protection | Vehicle connectivity is a key enabler of advanced vehicle automation. Data will therefore be the key enabler of the connected automated driving. Connected automated driving will require vast amounts of data to be gathered and processed for the benefit of all. While the need to ensure access to data is paramount for ensuring the full deployment of connected automated driving, the protection of personal data is essential, as well as cybersecurity. Users are willing to embrace connected automated driving, provided that they know which of their data is being shared and that they are given the choice with whom they share data. It should be needed more research on AVs black boxes and who will have access to the data.

User interface | In terms of security, another challenge concerns the human interaction. Automated vehicles should be able to understand the intent of other road users, especially of vulnerable road users, and interact with them like human drivers do, and the behaviour of automated vehicles should be predictable (without connectivity) by other road users, at least in the transition period. This is covered by the Thematic Interest Group on Human Factors.

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Ethics and liability | From an ethical perspective, an important challenge that has been addressed concerns the human complexity and driver's liability in case of road accidents. Since a human choice is based on a personal system of values that varies between individuals, it is crucial to establish how the automated system will decide on questions of life and death, e.g. choosing between putting drivers or pedestrians at risk. Whether the driver should be able to change the decision process of the car on such ethical questions, and accident liability should be removed from drivers of conditionally automated cars who show typical and reasonable user behaviour is still controversial.

User acceptability and cost | A further challenge refers to the extent to which automated transport might change our current mobility, especially with respect to public transport.

One of the main aspects to be taken into account is the desire to stay in control: A large number of people prefer to not go from private car to public transport because they enjoy having control of their journey, and automated road transport will take control from the users.

On the other hand, it needs to be considered if automated mobility will be more or less expensive, public transport will be still affordable or even more affordable and accessible, and availability of shared cars and other on-the-demand mobility services will be sufficient to answer the demands. The equity of citizens with respect to mobility in terms of cost of travelling and accessibility must be considered.

Driver training | Finally, the driver training is an important challenge to be addressed. Drivers should thoroughly be informed about when and how to use automation features and should benefit from adapted education and training to understand the basics of the technology. However, with a shift to automation level 2, 3 and beyond, driving and training will get more complicated. Therefore, transition needs to be gradual and simple for a non-expert public

Drivers will have to know how to operate different types of vehicles working on different systems and how to drive in different modes of automation. This is a challenge for car rental companies and car manufacturers, for instance. The driving licence should be linked to the level of automation of the car, but driver training might be useless as developments go too rapidly and drivers could not be retrained every time a new type of automation becomes available. A new traffic system will derive, and after familiarisation with automated vehicles, new means and methods of human driving behaviour will emerge.

Research Needs

The thematic interest group has identified the following eight areas in need of further research from a user perspective:

User centric approach | Stronger emphasis must be placed on user requirements, user acceptance and user outreach. The outcomes of research and innovation will only come to rapid deployment, if further efforts are made to reaching out to users, analysing their requirements and acceptance with the aim to overcoming market deployment barriers. More surveys and research work should be done to find out how automated driving will affect people and what kind of services and features users would like to have.

It will be needed some distinction when analysing CAD. Would it be for private and professional use, and also in terms of socioeconomic background, age, gender, disabilities etc. since the approach to AVs could be different.

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We need to investigate what groups will be worse off with road automation, for which groups the mobility will be improved by AD and how, and who will be the main players and how will they approach increasing automation. We should involve politicians (local, national and European) in research on acceptance of road automation.

User awareness | Future research should help to increase public acceptance of radical innovations and create communication/marketing messages to increase individuals' willingness to accept and buy ARTS. We have to focus more on user acceptance of new mobility services and less on technology acceptance.

User trust | Future research should help to assess individuals' first-time interactions with ARTS as well as individuals' feelings, thoughts and behaviours after prolonged experience with ARTS on use of ARTS, and try to understand how society would like to develop automated mobility. Future research should also help to assess the long-term effects of ARTS on driver behaviour, road safety, future travel needs and future mobility patterns.

Data protection | Data used to enable connected automated driving contains valuable information about individual and collective behaviours, about the performance of individual transport systems, infrastructures and vehicles, travel patterns and traffic flows, incidents and disruptions.

Research should help to analyse in how far competition in the market, user choice and the related societal benefits can be boosted through open data policies and open data standards and platforms. Research into the gathering and use of data in the context of connected automated driving should help clarify the current legal uncertainties, which are hampering the development of connected automated driving. Furthermore, considering the vulnerability of connected automated driving systems and the potential hazards malicious entry may cause, further research should be directed at better understanding specific threats to those systems as well as proposing and developing ways to address them, without compromising the needed connectivity and its benefits.

The cybersecurity aspect should not be put aside, more discussion and technical information to users should be provided in that matter.

User interface | Future research should study the interactions between human road participants and connected automated vehicles and systems, and how the "intuitive" behaviour of connected automated vehicles and systems will affect user acceptance. Harmonisation of vehicles features is needed to make it easier for drivers to use all type of cars.

Ethics and liability | Ethical questions should be addressed in order to define which level of safety is acceptable. Future research should help to develop a data management framework allowing appropriate open and secured access control; research into the gathering and use of data in the transport sector should help to clarify the current legal uncertainties.

User acceptability and cost | Future research should define the sequence of automated driving functionalities, how quickly the new functionalities could be installed and how they are to be paid. The added value of in-vehicle time when utilising connected automated driving should be taken into account. Moreover, we need to clarify whether the new intelligence will be embedded mainly in vehicles, in road infrastructure, based on highly accurate maps, or shared/a combination between these.

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Driver training | Future research should study how to manage the issues of mixed vehicle types (automated and non-automated) and mixed road types (motorways, country lanes, private roads), and make necessary driver training acceptable for the user.

Impact assessment

The thematic interest group has identified the following four main impacts and horizontal issues from a users' perspective:

Data Management. With connected automated driving systems, more data gets generated and used in the transport sector. As most of this data will be generated from recorded personal mobility behaviour, data protection, full informed consent and free sharing should be guaranteed for citizens.

Mobility. A new traffic system will emerge, where humans and automated vehicles will have to share the traffic environment. New rules and new behaviours will definitely emerge, and new mobility patterns will arise due to ART.

Ethics. Is road automation an autonomous process or are citizens and public authorities able to influence the direction it will take?

Health. ART might affect the public health by reducing or increasing the use of active transport modes.

Challenges

Challenge C1. Awareness, acceptance and trust: awareness is a key challenge to acceptance. The level of acceptance will be very low as long as the road users are not even aware of automated driving possibilities of today. After awareness, to be accepted, Automated Road Transport will also have to be trusted. And to be acceptable, an automated car will have to be much safer than regular, and users will have to trust that it's the case.

Challenge C2. Self-identity: for some people, a choice of car is also an expression of their personality and life-style. How this personality will be reflected with automated vehicles?

Challenge C3. Socio-economic and age group differentiation: the acceptance level can be different amongst the social groups. Older people may want to stay in control while younger group could have less trust issues, or vice versa if the older generations can prolong the use of their personal car with the assistance of (even lower-level) automated vehicle. Further aspects to be considered are cultural, age and generational differences.

Challenge C4a. Automated Road Transport challenges the desire to stay in control: a lot of people do not go from private car to public transport because they want to stay in control of their journey. Automated Road Transport will take control from the users. Will they accept that?

Challenge C4b. Automated Road Transport challenges the desire to stay in control: As in the shift from private cars to public transport, for an important group of people the main issue for not shifting is "I want to have control". How can we change this conviction? Fully automated cars probably already exist, but it will take a lot of time before fully automated cars will form the majority of the cars on our roads. In the meantime, semi-automated cars will differ from each other on the functionalities with which they are equipped.

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Challenge C5. Safety: If automated driving proves to be safer than non-automated driving, will it still be acceptable to drive a non-automated vehicle? And what level of safety is acceptable for automated vehicles, need it to be full-proof?

Challenge C6. How Automation will change our current mobility? Would automated mobility be more or less expensive? Will public transport still be affordable or even more affordable and accessible? Will availability of shared cars and other on-the-demand mobility services be sufficient to answer the demands? Will traffic flows down with automated cars?

Challenge C7a. Human complexity and diversity and ethics: What if any action the car make leads to a bad consequence? What if the car has to choose between putting the driver or a pedestrian at risk? A human choice is based on a personal system of values that varies between individuals, and it is taken under pressure. How the system will choose, when the decision has to be "pre-coded" by the programmer or is derived from machine-learning mechanisms that are not transparant? Will the driver be able to choose between different "modes"?

Challenge C7b. Human complexity, diversity and ethics: Should an automated car decide for the driver on ethical questions of life and death? Should the driver be able to change the decision process of the car on such ethical questions?

Challenge C8a. Human interaction: How to interact in traffic without human interaction? A lot of communication while driving is done directly human to human. At an advanced stage of automation, the human interaction will be removed from the equation. How the automated vehicle will react to a pedestrian waving at the car indicating that he doesn't want to cross? Will it be overcome? Replaced? And how can automated cars deal with cultural differences? In one country 'waving your hand at a car (driver)' may mean something different than in another country.

Challenge C8b. Human interaction: How will (semi-)automated vehicles communicate with and recognise the intentions of less or non-automated vehicles and other road users such as pedestrians and cyclists?

Challenge C9. Driver training: automation development should be based on realistic driver expectations and understanding of the operation of automated features (including system limits and use constraints). In order to facilitate technology deployment, drivers should thoroughly be informed about their vehicles' assistance systems and the related boundaries of such systems (activation, deactivation, failure). Existing systems should be fully reliable by the time they are available to the public and brought closer to citizens via targeted awareness-raising. Drivers should benefit from adapted education and training to acquire a working knowledge of when and how to use automation features, and to understand the basics of the technology. New requirements should be introduced in the European Driving Licence Directive to include driver assistance systems and regular refresher courses should be foreseen for licence holders as the technology develops.

Challenge C10a. More complex driving logic: During the first years of automation, a necessary familiarisation phase will occur for the drivers to be perfectly comfortable with this new technology. With a shift to level 2 and 3 of Automation, driving and training will get more complicated. Drivers will have to know how to drive different types of cars working on different systems; how to drive in different modes of automation. This is

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a particular challenge for car rental companies. Maybe there will be even different license. But driving would again become a lot easier when moving towards higher level of automattion.

Challenge C10b. More complex driving logic: How will driver training and the driver licence handle the differences between the functionalities with which semi-automated cars are equipped and in which environments and conditions they operate? Will the driver training/driver licence be car specific? What could be the role of the manufacturers in this?

Statements

Statement 1. Drivers need always to be fully aware of the vehicle's current level of automation and their level of liability. [#C1]

Statement 2. User acceptance can only be investigated if much more information about automation developments is given to the public. [#C1]

Statement 3. Awareness campaigns should accompany the progressive deployment of automation functionalities. [#C1]

Statement 4. We have to accept that users may not accept and even may reject road automation. [#C1]

Statement 5. Current models of user acceptance of new technologies are not suitable for acceptance of road automation. [#C1]

Statement 6. User acceptance is closely linked to political goals from both local and national authorities. [#C1]

Statement 7. Automated functionalities need to be designed with the user in mind, with user-friendly Human Machine Interfaces and sufficient lead time for drivers to resume driving if necessary. [#C2]

Statement 8. Interaction between ARTS and people of different cultural backgrounds must be taken into account. [#C3]

Statement 9. Interaction between ARTS and people of different age must be taken into account. [#C3]

Statement 10. Interaction between ARTS and people of different generations must be taken into account. [#C3]

Statement 11. There should also be a strong focus on the acceptance by institutional users (fleet owners, taxi companies, road authorities, etc.), not only on individual (private) drivers. [#C4]

Statement 12. The equity of citizens with respect to mobility will be affected by ART (cost of travelling, accessibility, etc.). [#C6]

Statement 13. The value of time spent travelling will be affected by ART. [#C6]

Statement 14. Road safety when automated vehicles are present in the traffic at varying levels of penetration should be studied. [#C7]

Statement 15. Accident liability should be removed from drivers of conditionally automated cars who show typical and reasonable user behaviour. In conditional automation mode, the vehicle should store data that

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helps to identify – in the case of an accident – who is liable whilst fully respecting data protection and privacy law. [#C7]

Statement 16. People should have the freedom to change options for the decisions taken by the cars (driving style, risk level, collision avoidance choices).

Statement 17. Automated vehicles should be able to understand the intent of other road users, especially of VRUs, like human drivers do, and interact with them, like human drivers do. [#C8]

Statement 18. The behaviour of automated vehicles should be predictable (without connectivity) by other road users, at least in the transition period. [#C8]

Statement 19. Requirements to the European Driving Licence Directive should include automated features and new vehicle functionalities with regular renewal opportunities on offer as technology develops. [#C9]

Statement 20. Driver training is useless, developments go too rapidly, we cannot retrain drivers every time a new type of automation becomes available. [#C9]

Statement 21: Car manufacturers /car dealers should provide car specific (taking the functionalities with which the car is equipped into account) driver training to people buying a new or second hand car. The same applies to car rental companies and people who rent cars with automated driving functionalities. [#C9]

Statement 22: The driving licence should be linked to the level of automation of the car (i.e. depending on your driving licence you can drive certain types of cars). [#C10]

Statement 23. A new traffic system will derive. After familiarisation with automated vehicles, new means and methods of human driving behaviour will emerge. [#C10]

Other Research Needs

Research input 1. Stronger emphasis on user requirements, user acceptance and user outreach. The outcomes of research and innovation will only come to rapid deployment, if further efforts are made to reaching out to users, analysing their requirements and acceptance with the aim to overcoming market deployment barriers.

Research input 2. Future research should help to develop a data management framework allowing appropriate open and secured access control. Research into the gathering and use of data in the transport sector should help clarify the current legal uncertainties.

Research input 3. Design “intuitive” behaviour of automated vehicles and how this affects acceptance.

Research input 4. Study interactions between human road participants and automated vehicles.

Research input 5. Who will be the main players and how will they approach increasing automation?

Research input 6. What will be the sequence of automated driving functionalities and will different actors adopt similar innovation paths?

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Research input 7. Will the new intelligence be embedded mainly in vehicles, in (general or highway) infrastructure, based on highly accurate maps or shared/a combination between these?

Research input 8. How quickly could the new functionalities be installed and how are they to be paid for?

Research input 9. How will the issues of mixed vehicle types (automated and non-automated) and mixed road types (motorways, country lanes, private roads) be managed?

Research input 10. Future research should help to create communication/marketing messages to increase individuals' willingness to accept and buy ARTS.

Research input 11. Future research should help to increase public acceptance of radical innovations.

Research input 12. Future research should help to assess individuals' first-time interactions with ARTS as well as individuals' feelings, thoughts and behaviours after prolonged experience with ARTS on use of ARTS.

Research input 13. Future research should help to assess the long-term effects of ARTS on driver behaviour, road safety, future travel needs and future mobility patterns.

Research input 14. We have to focus more on user acceptance of new mobility services and less on technology acceptance.

Research input 15. Future research should including visioning, trying to understand how society would like to develop automated mobility

Research input 16. We have to involve politicians (local, national and European) in research on acceptance of road automation

Research input 17. We need to investigate what groups will be worse off with road automation.

Research input 18. We need to investigate for which groups the mobility will be improved by AD and how.

Research input 19. We have to study the added value of in-vehicle time when utilising AD.

Research input 20. How we can make necessary driver training acceptable for the user?

Research input 21. Ethical question and which the level of safety is acceptable.

Impact assessment

1. With Automated Road Transport Systems, more data gets generated and used in the transport sector. As most of this data will be generated from recorded personal mobility behaviour, data protection, full informed consent and free sharing should be guaranteed for citizens.

2. A new traffic system will emerge, where humans and automated vehicles will have to share the traffic environment. New rules and new behaviours will definitely emerge.

3. Is road automation an autonomous process or are citizens and public authorities able to influence the direction it will take?

4. New mobility patterns will arise due to ART.

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5. Will ART affect the public health by reducing or increasing the use of active transport modes?

References

Adell, Driver experience and acceptance of driver support systems. A case of speed adaptation, Department of Technology and Society, Lund University, 2009

European Commission, Horizon 2020 - Work Programme 2016 - 2017 Smart, green and integrated transport

FIA Region I, Recommendations for the European Commission H2020 Work Programme 2018-2020, 2016

Madigan and al., Acceptance of Automated Road Transport Systems (ARTS): an adaptation of the UTAUT model, Transportation Research Procedia 14, 2016, pp. 2217 – 2226