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Towards recommendations for accessible and equitable public transport using CCAM

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Abstract

This paper looks at the use of and scope for Connected, Cooperative and Automated Mobility (CCAM) for road public transport in Europe (automated or semi-automated buses, shuttles or shared vehicles), in particular from the viewpoints of accessibility and equity for all users. It is based on work in the Horizon Europe project SINFONICA and leads towards recommendations for operators, authorities, vehicle manufacturers and demonstration projects with regard to ensuring that shifting towards CCAM in the public transport sector does not leave certain groups of citizens behind.

Keywords:

CCAM challenges: Standards, regulation, legislation and policy

Introduction

Connected Cooperative and Automated Mobility (CCAM), which includes automated / self-driving road vehicles (AVs) as well as driver assistance technology, is a rapidly developing sector in the transport and mobility sphere. However, it comes with implications for users as well as non-users (such as pedestrians and cyclists). People with specific needs, such as (potentially) vulnerable users and other people with mobility challenges (PMC), risk being excluded from such technology. Where CCAM is used in the public and shared transport sector (as opposed to private cars), this creates a problem for equity and inclusivity.

CCAM-based public transport in Europe has to date been mostly in the demonstration phase, with (often limited or short-term) services offered to the general public as part of a trial or demonstration within a nationally or EU-funded research project. In most cases, these have used small vehicles (e.g. self-driving shuttles with a capacity of up to ten persons), on short routes and at low speeds. A few demonstrations have used larger vehicles, driving at higher speeds, but always with a safety driver. In most cases, these demonstrations have been primarily to test the performance of the vehicles and associated technologies in different road and traffic situations, rather than to provide a service for regular passengers, either complementing or replacing elements of traditional public transport.

The EU project SINFONICA is looking at the implications of CCAM services on PMC, with different types of services, vehicles and staffing configurations. Issues to address include: which public and shared transport use cases are most suitable for CCAM? Which are the short-term quick wins and which are more challenging scenarios that will take longer to solve? In what circumstances (vehicle type and capacity, speed, route) should there be a safety driver, assistant or steward on board? Where this is needed, what is the advantage of automation if it does not reduce the need for staff? For unstaffed vehicles, how can PMC interact with them and use them?

Use of social indicators

SINFONICA Deliverable 5.1 "Equity practices and social indicators" focused on completed CCAM projects in Europe and the equity practices and social indicators used in them. It carried out a review of 40 EU CCAM-related projects (running between 2016 and 2022), together with a small number of national activities. These projects focused on:

- strategic issues, e.g., governance, emerging business models, acceptability (9 projects);
- public transport, e.g. autonomous buses and shared services (7 projects);
- acceptance of automated vehicles (AVs), related to technological aspects, and acceptability concerning social issues (12 projects);
- implementation of new technological solutions (12 projects).

The social equity issues most commonly found in these projects were acceptability and accessibility (in 72% of the sample of 40 EU projects), in particular in the clusters of projects dealing with public transport and acceptance of AVs. In the public transport cluster, pursuing accessibility for everyone, regardless of physical or cognitive impairments, was a social indicator in 45% of these projects. On the other hand, affordability was only considered in 10% of the EU projects analysed.

Concerning the types of users most frequently addressed in the analysis of social equity, the main groups focused upon were elderly people (over 65 years old) and people disabilities. However very few (4-5%) dealt with issues pertaining to young people, people on low incomes or in poverty, and digitally vulnerable people. Given that children, teenagers and young adults are key users of public transport, and also people with low incomes disproportionately use public transport, this is a gap that has not adequately been addressed by those working on CCAM. As for digitally vulnerable people, an increasing number of public and shared transport services (whether CCAM-based or not) either require an app, an email or mobile phone number to book and use. Although most people have smartphones nowadays, many elderly or people with cognitive impairments are unable to use one, and consequently risk being excluded from new and innovative mobility services.

A key aspect of SINFONICA was to address all these groups in a series of workshops, interviews, focus groups and surveys to provide fresh insights on some of the user's needs overlooked by the state-of-the-art research in the field of public and shared transport using CCAM.

CCAM public transport: state of play in Europe

The SINFONICA project built up knowledge on what CCAM trials and services are (or were recently) operational around Europe, focusing on public or shared transport services that can be used by any citizen (not closed trials). The purposed was to create typologies of services on which to base a set of typical use case scenarios. Data collection included a questionnaire as well as information from deliverables and websites of projects/trials. 16 projects were analysed (some with only partial data), covering 40 individual pilot sites or services.

Use cases for public and collective transport

The majority of services surveyed had a fixed route, timetable and stops. The main reason was that these projects had the key objective of demonstrating autonomous or semi-autonomous vehicles, and that making the service demand-responsive as well was a complication both operationally and potentially reducing the number of people who would use it.

Service frequency ranged from one service per hour to a service every four minutes. Most were every 15 or 30 minutes. Most ran during the daytime only, sometimes only at peak periods or only in the off-peak; very few ran on Sundays and only one ran in the evening. This is mostly for operational reasons (only one vehicle being trialled, so needs to take recharging breaks) and also because of the nature of most of the services, for example serving business parks where there is little or no demand at evenings or weekends.

The route length varied from 0.5 km to 22.5 km, the latter being a full-size bus with a safety driver (CAVForth service AB1 in eastern Scotland). However most were in the 1.5 to 5 km range (only three services surveyed were over 5 km in length). There have therefore been no known trials in Europe of CCAM public transport operating a full service (early morning to late evening, seven days a week). This indicates that the use of AVs to take over regular scheduled bus services is still not imminent and some issues still need to be addressed.

Regarding road types, almost all were on low-speed urban roads, with a few on low-speed rural roads. Only one (CAVForth) used motorways or expressways and one (MultiCAV, in Oxfordshire, England) used a major road outside a built-up area. Both of these services were controlled by a safety driver.

Nine services identified ran on demand (in France, Switzerland, Denmark and Luxembourg). In all cases, the route remained fixed, only the timings were flexible according to user demand, usually with booking using an app or website. There were no examples of flexible routing using full AVs. This is an unexplored area of research with many challenges (suitability of the roads, safety of pick-up/drop-off points, how to prioritise conflicting travel demands from different passengers, how to treat late or no-show bookings, etc.).

Vehicle types and driver/personnel

Where the automation level was known (SAE scale), this was normally level 2 or level 4. On over 80% of the services surveyed, standing passengers were not permitted.

Most services surveyed used an automated or semi-automated mini-shuttle, with between 4 and 12 seated positions. Where standing was allowed, standing space was for between 4 and 14 passengers, and all vehicles had space for one wheelchair. In most cases a commercially produced vehicle was selected, with criteria being the best type of vehicle to use in mixed traffic, with safety and reliability being of paramount importance. Hence, the vehicles used are mostly small ones. Mostly, no retrofitting for accessibility was done as the vehicles were already accessible. The maximum permitted speeds of these vehicles were between 16.5 and 40 km/h, but mostly at 25 km/h. However actual operational speeds were lower. In most cases, the service was free to users.

All had an on-board steward or assistant, as they were trials, so a member of staff was needed to reassure passengers and also ensure correct passenger behaviour. Four of the services were double-manned, having both a safety driver and an on-board steward, but it is unlikely that a CCAM service in everyday public use would have two staff members. One trial included staff members at the stops (the service only ran between two bus stops). Clearly on an everyday bus service with numerous bus stops, some would have to be on request (so as not to cause delays if nobody needed to board or alight at a certain stop) and the stopping and door opening would have to be selective.

The only known service to use a full-size bus was the CAVForth service operated by Stagecoach in Scotland. This vehicle (standard diesel bus) has a capacity of 36 seated passengers and a wheelchair, as well as a traditional driving cab so the driver can take over when required. The typical top operational speed of this service is 80 km/h (50 miles per hour) on motorway and expressway sections. Although the vehicle has space and facilities for standing passengers, for this service standees are not allowed, and passengers are required to wear seatbelts. The driver's role is also one of customer service, including issuing and checking tickets and passes.

Reasons for use cases

The trials and services surveyed were chosen for different reasons, such as last mile (between entrance of a restricted area to several office buildings on a site), linking an economic zone or business park to a railway station, potential to test integration of CCAM bus services with rail services (multimodal journeys), linking rural areas on the periphery of a town or small city, and linking a hospital site, and testing the vehicle on various types of roads.

Summary of feedback and issues encountered

Feedback included technological, operational and user aspects. Regarding user aspects, passengers who gave positive reactions to low-speed automated shuttles often felt that their perception of safety might worsen if it was a larger sized bus with no attendants on board, travelling at regular traffic speeds. Most of the services surveyed operated at very low speeds and passengers generally considered them to be too slow for everyday purposes such as commuting to work, so they would be unattractive compared to other modes. Some passengers commented on the small size of vehicles, saying that people are sitting too close together and that it would need to be larger to accommodate luggage and shopping bags.

As most vehicles had a member of staff on board (even if it was a full AV), there was no feedback on how users would feel e.g. late at night in case of antisocial behaviour. One aspect is that public transport using AVs assume that all people would be respectful and follow the rules, whereas this is not true in reality and PMCs in particular can be put off public transport as much due to the behaviour of others than by the technology itself.

Towards recommendations

SINFONICA is currently finalising recommendations for all kinds of CCAM operation, whether in a demonstration project or as a more permanent service, provided commercially or by (or under contract to) a public authority.

Policy: Rules and regulations

More harmonised rules are needed for establishing regulations for road and vehicle design to ensure safety, including travel assistance if needed, to people with mobility challenges. This requires collaboration between vehicle manufacturers, transport operators and policy makers. At local and regional level, there is a need for clear rules on the public service obligations that transport authorities impose on transport operators about the introduction of CCAM services for people with mobility challenges.

Policy: Market-based instruments

There is a need for public incentives and subsidies to promote CCAM adoption, especially during the initial phases. The willingness to invest of operators may be limited unless public subsidies or a clear short-to-medium-term profit potential is available. The role of EU and national projects and programmes funding for R&D and trials can play an important role in setting up viable business models.

Policy: Infrastructure development

Consider the need for dedicated rights of way for CCAM public and shared transport, where possible (possibly shared with other public transport) in order to allow faster commercial speeds in a safe environment, with greatly reduced traffic conflicts. In this context, segregated roadways or lanes with a physical barrier (such as a kerb) between it and general traffic, and barrier or bollard-controlled entry/exit, to prevent unauthorised vehicles. Other specific vehicles, such as traditional buses and emergency service vehicles, could have access to such rights of way, provided their drivers are trained in interacting with higher speed automated vehicles.

Implement smart traffic management systems such as detection of CCAM public transport and traffic signal / junction priority, to reduce delays and also to reduce the likelihood of sudden stops which can be uncomfortable or dangerous for passengers.

Establish a clear hierarchy of traffic modes, including CCAM public/shared transport vehicles, with respect to integrating infrastructure and driving/access/priority rules into strategic urban planning (e.g. SUMPs).

Service planning and specification recommendations

Demonstration projects are temporary and generally have objectives other than providing a transport service, e.g. to test different types of vehicles or technologies under different conditions: road infrastructure, terrain, speeds, traffic conditions, etc. Nevertheless, such projects should be a prelude to wider roll-out of CCAM, so they need to provide results that assist such deployment beyond the direct technical scope of the project.

The type of service operated should therefore be as close as possible to standard public or shared transport service, e.g. in terms of frequency, speed and attracting a range of different kinds of users (trip purposes and social characteristics), including people with potential mobility challenges or vulnerabilities.

Often a project will run a demonstration free of fares/ticketing in order to attract users over a limited demonstration period. If this is the case, consideration should be given to how ticketing, fare payment and control would take place in a theoretical full-scale operation. This should include research with customers of the future full-scale operation.

For services where hailing, booking or payment is required, there should be an option for this to be done without needing a smartphone app, both for those without this technology (or unable to use it) and for occasional, one-off travellers, who do not wish to download an app and set up an account just for a single journey.

One of the most common critical topics in user feedback received by CCAM demonstrations is the slow speed of the vehicle, with users questioning whether such speeds would make the service practical or attractive compared to other modes. Trials should consider different kinds of CCAM services at more usual traffic speeds, including on interurban and rural routes.

Integration with other modes is important, and CCAM demonstrations should, where possible, provide integration with other public transport services (such as a last-mile connection) or allow multimodal trips, such as park-and-ride.

Vehicle, staffing and operation recommendations

Vehicles should be accessible as possible, meeting national accessibility standards as a minimum. Wheelchair access / access for those with luggage is an important feature, as well as ramps, lifts or other facilities for level boarding. Interior features should include handrails and grips (with contrasting colours), stop request and emergency buttons, in-vehicle displays (route, next stop, etc.). Needs of people with hearing and sight impairment or loss should be included, as well for people with walking frames, luggage, children, etc.

The doors should be easy to control (if passenger-operated) and it should be clear whether the passenger is expected to request stops and open the doors, or whether this is done by an operator (in-vehicle or remotely) or automatically.

One of the potential benefits of fully automated vehicles is to reduce labour costs and/or allow additional services to operate that might be financially prohibitive otherwise. However in most cases of demonstration projects, either a safety driver or steward/assistant is on board in order to explain the concept and service to passengers, provide information and to reassure them. Projects need to specify what level of staffing is appropriate and, importantly, the role(s) of any staff members on board, including whether there is a driving position in the vehicle or not. In the case of small shuttles without a driving position, staffing could be optional, but then there needs to be an accessible way for two-way communication between the remote operator and the passengers. There should also be a way for passengers to book or summon an assistant if needed. For vehicles with a driving position, which will – in the medium term at least – be the majority of larger vehicles and ones travelling at higher speeds, the specification and training for the drivers needs consideration, including under what circumstances (if any) the driver is allowed to leave their seat to attend to passengers' needs whilst the vehicle is in motion.

The vehicle configuration (whether standing is allowed or all-seated, and in the latter case whether seatbelts are required) depends on the expected speed of the service and the types of roads it will operate on. Typically standing is allowed on urban buses, up to around 50 km/h, but for fully automated vehicles, which might brake more suddenly in case of an obstruction, the maximum speed where standing passengers are allowed might need to be lower. This links also to frequency: if all seats are taken in a small vehicle and standing is not allowed, people will be left waiting at bus stops and excluded from the service, sometimes causing great inconvenience in the case of essential trips. Therefore, either the frequency needs to be very high, or some kind of booking mechanism will be required, so that users have certainty that they will be able to make their desired trip.

Travel route information should be always available and clearly visible on the vehicle, especially in cases where no driver or assistant is present. On-board real-time updates on diversions and unforeseen events must be provided promptly, along with possible alternative routes. This could be via static screens with text and announcements so people with hearing or a visual impairment get all the information. The information should be designed to be accessible to all users and available inside the vehicle, at bus stops, and online. For example, there could be video screens that one can use to get extra assistance in the vehicle and at the stops. They could talk to a person that provides extra assistance and information.

Passengers should have the option to change their trip, for example getting off at an earlier stop (in cases where trips are booked). There should also be CCTV monitoring for passenger safety and security, including alerting the operator to any antisocial or disruptive behaviour by passengers or others.

Data collection and evaluation recommendations

Key Performance Indicators in the following domains should be used to benchmark ongoing and future CCAM projects with respect to social equity:

- Safety and feeling of safety. Typically measured as several fatalities, injuries, or property damage for vehicle occupants or other road users, but also rider perception, including personal security aspects.
- Vehicle operations. Influencing the reliability and acceptability of CCAM, some indicators on vehicle operations, e.g., time headway, reaction time, adaptability time, etc, should be evaluated.
- Economic impacts. In terms of social equity, indicators measuring the impacts of AVs on the labour market should be considered: not only replacement of drivers but also new tasks such as on-board assistant / safety operator.
- Land use. Space efficiency, in terms of number of road space and bus stops / parking areas.
- Cost: Both in terms of operational costs (technology, new vehicles, staffing) with respect to traditional bus services, and cost to the user and public authority (fare level, level of public subsidy).
- Reliability and attractiveness: Is the service suitable for everyday use, e.g. commuting, shopping, etc. and is it an attractive alternative to a car, taxi or traditional bus service in terms of journey time, availability, convenience, comfort and price?

The above domains should be integrated in the basket of KPIs addressing the four A's: accessibility, affordability, availability and acceptability.

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