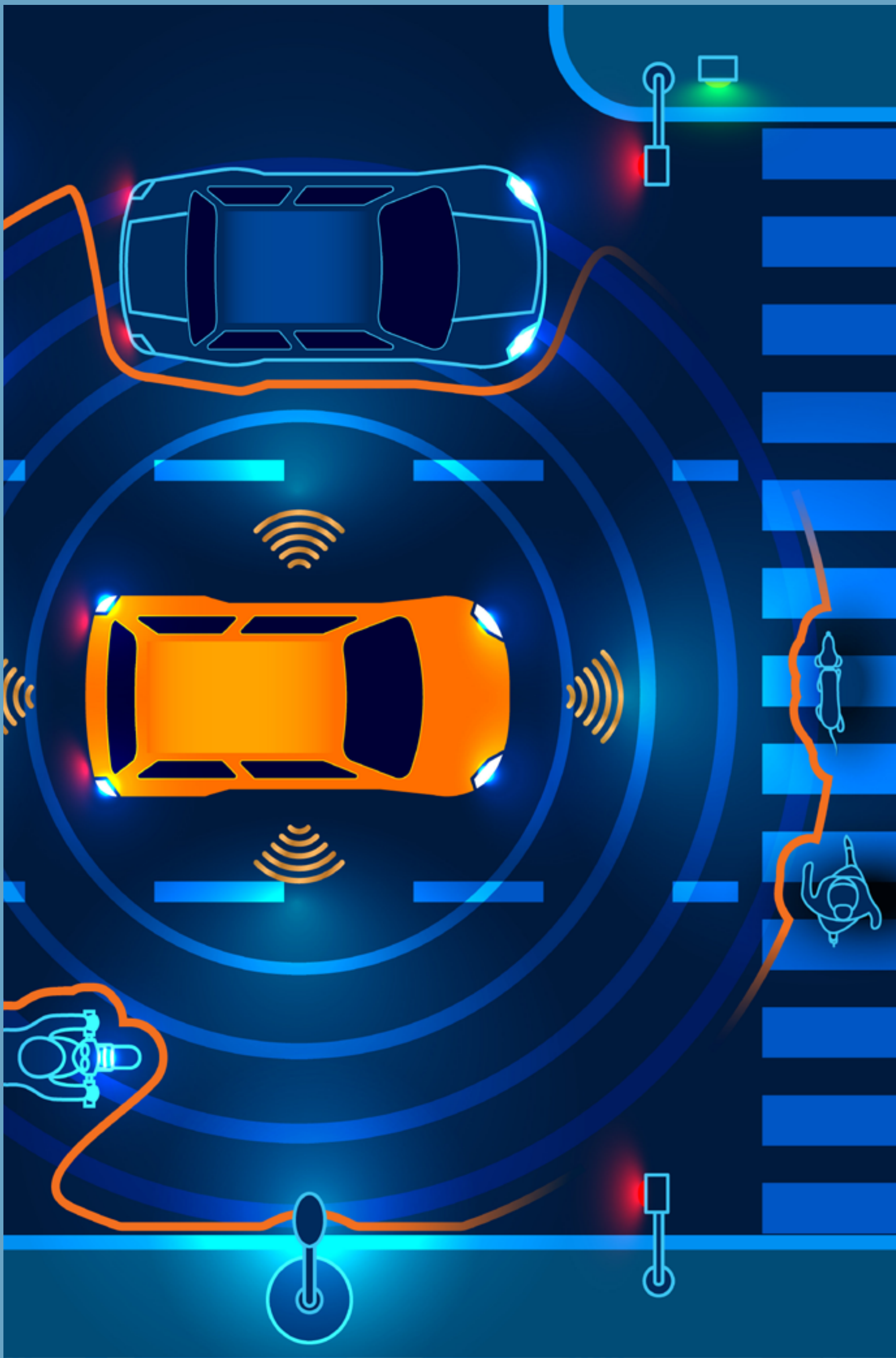


SRIA

STRATEGIC RESEARCH AND INNOVATION AGENDA

2021 - 2027

European leadership in safe and sustainable road transport through automation

CCAM
CONNECTED, COOPERATIVE & AUTOMATED MOBILITY

Co-funded by the European Union

1. Table of contents

2. Preface

The CCAM (Connected Cooperative Automated Mobility) Partnership is a public private partnership, which aligns all stakeholders' R&I efforts to accelerate the implementation of innovative CCAM technologies and services in Europe. It aims to exploit the full systemic benefits of new mobility solutions enabled by CCAM: increased safety, reduced environmental impacts, and inclusiveness. The Partnership will develop and implement a shared, coherent and long-term R&I agenda by bringing together the complex cross-sectoral value chain actors with the joint vision: "European leadership in safe and sustainable road transport through automation".

This Strategic Research and Innovation Agenda (SRIA) is the multiannual roadmap, guiding the CCAM Partnership. It describes the CCAM Partnership strategy for achieving the expected impacts, the corresponding portfolio of activities, the resources, and timeline. It sets the Partnership's objectives and defines the process for identifying and prioritising the research and innovation activities needed to achieve these objectives.

The CCAM SRIA is the basis for the CCAM Partnership under the Horizon Europe Programme.

3. Introduction

3.1 European Partnership in Horizon Europe

The aim of European partnerships in Horizon Europe[1] is to deliver on global challenges and modernise industry. European Partnerships are key implementation tools, contributing significantly to achieving the EU's political priorities. The Partnerships are formed between the European Commission and private and public stakeholder addressing Europe's most pressing challenges through coordinated research and innovation actions. By bringing private and public partners together, European Partnerships help to avoid the duplication of investments and contribute significantly to leveraging public funding through private investments.

3.2 The Rationale for CCAM

Mobility is crossing a new – digital – frontier, allowing vehicles to communicate with each other, with the road infrastructure and with other road users. This will enable a coordination and cooperation between road users, and managing traffic and mobility at an entirely new level (e.g. warning messages not limited by line-of-sight or congestion management using real-time information and targeting system optimum traffic flows distributions).

Current road vehicles already provide advanced assistance systems and intervene when a dangerous situation is detected. Future systems will have 360° vision of the surrounding environment, significantly reduced reaction times and will be able to control the vehicle for extended periods and, at some point in the future, will no longer rely on human back-up.

> Combining connectivity, cooperative systems and automation will enable automated and fully orchestrated manoeuvres, bringing us closer to Vision Zero.

Cooperative, Connected and Automated Mobility (CCAM) is expected to reshape the way we travel and move, not only in Europe, but around the world. With CCAM, the vehicles are well integrated into the mobility and transport system, its infrastructure, operations and new services. In theory, fully connected and automated vehicles could substantially increase existing average road infrastructure capacity[2] by smoothing traffic flow, while enabling off-peak usage of infrastructure for freight transportation (e.g. night- time deliveries). Smart traffic management will further increase efficiency and reduce congestion by enabling improved access and distribution of vehicles over the road network. CCAM enabled shared mobility services will enable seamless integration with public transport and Mobility-as-a-Service (MaaS) platforms. It will provide accessible mobility to people who cannot drive (e.g. incapacitated or disabled people, and those without a driving license), or who no longer want to drive. Furthermore, by offering driverless transportation solutions, CCAM can provide vulnerable people with mobility and options for goods deliveries at low health risk, which is particularly important in epidemic situations like the COVID-19 pandemic.

> CCAM enables more user-centred, all-inclusive mobility, while increasing safety, reducing congestion and contributing to decarbonisation.

1 https://ec.europa.eu/info/horizon-europe/european-partnerships-horizon-europe_en

2 New Technology and Automation in Freight Transport and Handling Systems. Daniela Paddeu, Thomas Calvert, Ben Clark, Graham Parkhurst, University of the West of England, Bristol. UK Government Office for Science. February 2019.

Automated public transport services will deliver profound changes, not only in how people travel, but also in the way of life. The usage of shared CCAM is expected to bring a tide of benefits, including: flexible, customizable, more widespread and accessible services, reduced noise and air pollution, and better use of urban space, while providing a safer, more comfortable and integrated travel experience.

As concerns freight and logistics, the shortage of truck drivers, in particular for the long haul, and the demand for better working conditions requires higher levels of automation that could support further transport productivity[3]. According to the European Transport Workers Federation and the International Road Union, a shortage of 21% professional drivers exists across the freight transport sector[4] . Moreover, CCAM coupled with innovative fleet management may enable larger quantities of freight to be transported compared with current operating practices, and guarantee the same transit time even at lower speeds (thus. saving energy)[5]. Additionally, platooning and higher-levels of automation can increase the resilience of supply chains by enabling goods to move with less, or even without, human intervention, broadening access to citizens and destinations in critical areas or under exceptional circumstances such as pandemics[6] .

CCAM is expected to bring operational efficiency to logistics hubs, integrating road transport with other logistics operations; for example, if truck arrivals at a terminal are known beforehand, yard planning can be made more efficient by avoiding congestion in the hub area. Moreover, autonomous systems could facilitate last mile operations between logistics centres and port terminals[7], hence reducing barriers for intermodal transport.

CCAM enables the provision of new mobility services for passengers and goods, fostering benefits for users and for the mobility system as a whole.

CCAM will have a remarkable economic impact. McKinsey found in their "RACE 2050"[8] report, that the economic value contribution of CCAM is one of the core requirements to create a profitable future mobility industry and maintain relevance as a global export industry. According to the McKinsey Auto 2030 model[9], European automotive revenues based on consumer spending will almost double from EUR 850 billion in 2016 to EUR 1,400 billion by 2030.

Europe has the unique opportunity to consolidate its leading role in connected, cooperative and automated mobility against rising competition in global value chains and markets by using its strengths in vehicle and system innovations to promote socio-economic benefits and sustainable development. The European Patent Office (EPO) stated in a recent report[10] that the number of related European patent applications in the area of CCAM (see Figure 1, patent statistics between 2011 and 2017) is growing 20 times faster than for other technologies. The study shows that Europe accounted for 37.2% of all patent applications related to self-driving vehicle technologies at the EPO between 2011 and 2017 - ahead of China (3%), Japan (13%) and the United States (33.7%).

3 Tavasszy, L.A. (2016). The value case for truck platooning, working paper, Delft University of Technology. Doi 10.13140/RG.2.2.13325.54247

4 https://www.iru.org/resources/newsroom/iru-and-etf-urge-eu-address-unprecedented-driver-shortage-road-transport-industry

5 in line with the Physical Internet concept: Ballot, E. et al. (2014) The Physical Internet: The Network of Logistics Networks. Paris, France: La documentation Française.

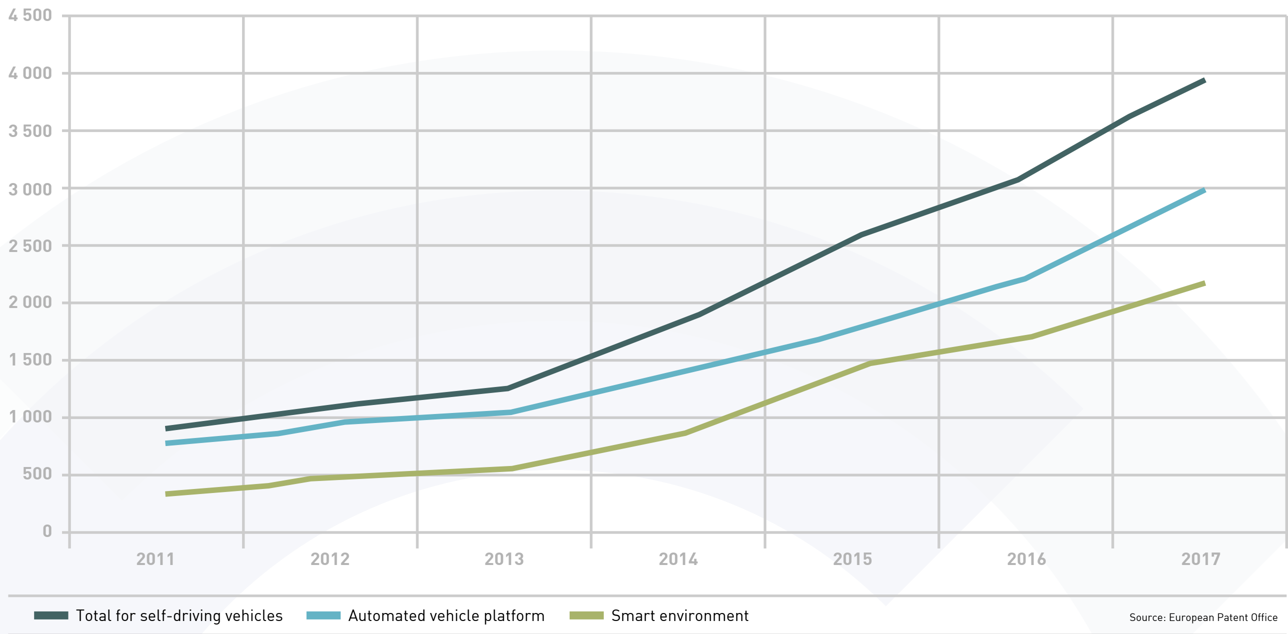
6 Robots And Drones Are Now Used To Fight COVID-19, 18.03.2020, https://www.forbes.com/sites/bernardmarr/2020/03/18/how-robots-and-drones-are-helping-to-fight-coronavirus/

7 Vera's First Assignment, 13.06.2019, https://www.volvotrucks.com/en-en/news-stories/magazine-online/2019/jun/Veras-First-Assignment.html

8 McKinsey, RACE 2050: Accessed at: https://www.mckinsey.com

9 McKinsey, Automotive revolution – perspective towards 2030, Accessed at: https://www.mckinsey.com

10 Sharp rise in patent applications for self-driving vehicles in Europe, new study finds, 6.11.2018, https://www.epo.org/news-issues/news/2018/20181106.html



The patent statistics in this figure are based on patent applications filed at the Epo in self-driving vehicle technologies. They do not include patent applications filed with the national offices of the contracting states of the European Patent Convention. The reference date for each application is the filing date at the EPO.

Figure 1: Patent applications at the EPO in self-driving vehicle technologies and their sectors 2011-2017

The development of CCAM shall provide benefits to all citizens. With full integration of CCAM in the transport system, the expected positive impacts for society will be:

- **Safety**[11]**:** Reducing the number of road fatalities and accidents caused by human error;
- **Environment and efficiency**[12]**:** Reducing transport emissions and congestion by optimising capacity, smoothening traffic flow and avoiding unnecessary trips;
- **Inclusiveness:** Ensuring inclusive mobility and goods access for all; and
- **Competitiveness**[13]**:** Strengthen competitiveness of European industries by technological leadership, ensuring long-term growth and jobs.

3.3 The Rationale for the CCAM Partnership

CCAM has a great potential to contribute to key policy goals like the UN Sustainable Development Goals[14] (SDG), Vision Zero[11], the European Green Deal[15], Europe fit for the Digital Age[16] and the Smart and Sustainable Mobility Strategy[17] (see chapter 3). Despite all the expected positive impacts, deployment of CCAM solutions is not yet happening. The Problem Drivers (PD) that hinder the implementation of CCAM (see chapter 6 for more details) are:

11 Vision Zero: by 2050, move close to zero fatalities and serious injuries in road transport. In line with this goal, the EU aims at halving road casualties by 2030. (https://ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/3rd-mobility-pack-factsheets-safety.pdf).

12 "Automated and connected multimodal mobility will play an increasing role, together with smart traffic management systems enabled by digitalisation. The EU transport system and infrastructure will be made fit to support new sustainable mobility services that can reduce congestion and pollution", European Green Deal, COM(2019) 640 final.

13 GEAR 2030 final report

14 Take action for the Sustainable Development Goals, https://www.un.org/sustainabledevelopment/sustainable-development-goals/

15 The European Green Deal, COM(2019) 640 final, Brussels, 11.12.2019, https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf

16 Six Commission priorities for 2019-24, https://ec.europa.eu/info/strategy/priorities-2019-2024_en

17 Sustainable and Smart Mobility Strategy – putting European transport on track for the future; COM/2020/789 final; https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0789

- Insufficient demand as society does not yet understand the potential benefits of CCAM enabled mobility. The long-term implications, benefits and impacts of integrating CCAM solutions into the mobility system are not sufficiently examined. (PD1)
- Although vehicles with higher level of automation are already starting being deployed on EU roads, their integration into CCAM solutions is not yet sufficiently mature and current investment levels in CCAM R&I are inadequate to maintain and extend EU industrial leadership. (PD2)
- Current R&I efforts are fragmented and lack a coherent, longer-term vision and strategy for targeting systemic solutions. (PD3)
- Demonstration and scale-up is limited since a well organised, extensive and complex cross-sectorial value chain is still required to build complete CCAM solutions. (PD4)

Addressing the four Problem Drivers in a coordinated and concentrated manner requires a shift in the mobility innovation process regarding user-involvement, timing and outreach. In the past, big innovations in vehicle technology like seat belts or airbags were introduced by industry as another component to the existing vehicle. After five to ten years of experience with these new technologies, technical standardisation (e.g. ISO standards) gave a thorough basis for developing regulations. Making CCAM solutions ready for deployment (Deployment Readiness[18]) requires that R&I, standards and regulation advance in a synchronised way. Today, vehicle technology is starting to lead to standards, and first steps of regulation have become available to introduce automated vehicles to the market. However their contribution to enabling CCAM services still lags behind, with steps to be done on traffic rules and harmonization across borders. To solve this situation, the most flexible and closest possible cooperation between actors and users involved in research, standardisation and regulation (national and international) is key for accelerating deployment and generating users´ and societal demand at the same time.

There is a strong need for EU-wide harmonisation and interoperability of technologies and methodologies for economies of scale, while considering societal aspects and regional differences. The development of methods for impact assessment and safety validation shall provide tools to meet society's needs and to share knowledge and compare results across Member States. Actions will develop technical specifications for interoperability, making sure that investments at local, regional, national and EU level, both of public and private nature, are complementing each other in making CCAM a key contributor towards a fully integrated European mobility system. Commitment towards coordinated European actions are needed to develop this eco-system with vehicle manufacturers and their supply chain, with local and regional authorities, road operators, service providers, telecom industry, research organisations etc. This coordination at EU level is fundamental to develop harmonised and interoperable solutions. Stakeholders will cooperate and co-create with citizens all over Europe, shifting the innovation process for new mobility services for people and goods toward user needs (e.g. in living labs).

> Although vehicles with higher level of automation are starting to be deployed on EU roads, their contribution to enable CCAM services will still need large-scale testing, demonstrations and pilot projects involving all relevant stakeholders to accelerate implementation and remove barriers[19].

18 Deployment Readiness is a status defined by combining the validated safe system functioning, a good understanding of the expected impact and potential risks, with users' and society's readiness to accept, adopt and demand CCAM solutions. It can be measured by e.g. number of successful pilots or field operational trials, participants involved, number of deployed vehicles.

19 European Commission DG Grow, Policy and Stratgie, Sectors: Automotive Industry, https://ec.europa.eu/growth/sectors/automotive/policy-strategy_en

Due to partly insufficient technical maturity and multi stakeholder involvement, these large-scale demonstrations actions are highly cost intensive and require significant resources. The involvement of a large cross-sectoral value chain and interaction between public and private stakeholders is another barrier for deployment of CCAM solutions.

These complex and multi-faceted challenges need more than the development of technologies. A systemic approach involving multiple sectors and a complex eco-system of diverse stakeholders is required. A European Partnership provides the ideal framework to streamline R&I actions across Europe supporting the transformational change of the industry and accelerate innovation.

4. The CCAM SRIA: developed in co-creation

4.1 Purpose of the SRIA

The SRIA is the basis for implementing the CCAM Partnership: the content of the SRIA will be further specified in the work plans, which will define the concrete actions to be implemented every year. This implementation process is described in chapter 10. The SRIA provides a flexible background for identifying and defining call topics for research and innovation activities to be included in the Horizon Europe Work Programmes. It also serves as a basis to develop shared activities with national programmes and other Horizon Europe Partnerships.

The CCAM Partnership serves as a "means to an end": the SRIA describes a comprehensive roadmap to deliver on its objectives within the defined timeframe. Reaching the Partnership objectives and Deployment Readiness at the end of its duration (or earlier) will allow the CCAM stakeholders to move to the next investment phases (industrialisation, competitive development, infrastructure deployment). In case of the CCAM Partnership objectives become unlikely to be reached, exit strategies are foreseen: modifying the SRIA, looking for additional partners, or as ultimate decision, ending the Partnership prematurely.

Radical technological progress in an area relevant for CCAM, or very slow progress towards key objectives could either require an adaptation of the SRIA, or could make its targets obsolete. The SRIA will be updated in the course of the Partnership, in case of major technological advancements, emerging opportunities and challenges, as well as evolving needs. Indeed, even though the SRIA covers the full duration of the Partnership in Horizon Europe, we foresee the need for validity checks, at least every two years, against recent and ongoing developments. This regular update process shall support the Partnership's flexibility. As soon as significant changes are identified, the SRIA document shall be updated.

The SRIA is the result of a process in which all partners collaborate to link the vision of the Partnership to a portfolio of R&I actions. It also forms the basis for annual or multiannual work plans and defines the long-term logic of actions that will allow the CCAM partnership to reach its objectives. The SRIA follows and complements the CCAM Partnership Proposal[20] (submitted to the European Commission on 13th April 2020). The commitment of the partners (see table below) to the SRIA is the basis to launch the CCAM Partnership under the new Horizon Europe programme.

The CCAM Partnership was officially inaugurated during the European Research and Innovation Days on 23 June 2021. At that moment, the CCAM Association, which represents partners other than the Union, boasted an impressive membership of nearly 170 participants. In order to ensure accessibility for all those interested, the membership application form is continuously accessible on the CCAM Association's website: ccam.eu.

Furthermore, to enhance the visibility of the Partnership and to inspire fresh engagement, representatives from the CCAM Association Secretariat consistently attend prominent events such as EUCAD, RTR, and TRA conferences, as well as the ITS European Congress and other significant gatherings. Thanks to these dedicated efforts, by July 2023, the CCAM Association has expanded its membership to exceed 215 esteemed participants.

20 Draft proposal for a European Partnership under Horizon Europe Connected, Cooperative and Automated Mobility (CCAM) Version 13 May 2020, https://ec.europa.eu/info/sites/info/files/research_and_innovation/funding/documents/ec_rtd_he-partnerships-connected-and-automated-driving-ccam.pdf

Table 1: CCAM Association Stakeholders

CCAM Association stakeholders as of 13 December 2023	
Automotive manufacturers	BMW, DAF, Daimler Truck, Ford Otosan, Otokar, Renault, Scania, Volkswagen AG, Volvo Cars, Volvo Group
Automotive supply chain	ACTIA Group, Applied Autonomy, Bias, Bosch, Buyutech, Continental, Denso, dRISK, EasyMile, Eurocybcar, Faurecia, Hitachi Europe, IFEVS, Infineon, IVEX, Michelin, Mosaic Factor, Provizio, Siemens, Valeo
Physical and digital infrastructure	ACISA, Alstom Transport, Bercman Technologies, Canon CRF, CEDAMaps, Digitrans, EHT SCpA, Ericsson, ETRA, Huawei, Hypervisoul, MAP Traffic Management, NTT Data, Royal Haskoning DHV, SMLLLondon, YunexTraffic
Universities	Aalto, ACE Mobility, Brno University of Technology, Budapest BME, Chalmers, FH Steyr Upper Austria, Halmstad University, Istanbul Okan, JKU Linz, KIT Karlsruhe, KUL Leuven, Limerick, Metropolia, Mondragon, Oulu University of Applied Sciences, Pfozheim University, Polytechnic Bari, RWTH Aachen, Tampere University, Technische Hochschule Ingolstadt (THI), Technological University of the Shannon, Trinity College Dublin, TU Delft, TUe Eindhoven, UCL London MaaSLab, Unina, Univ-Eiffel, Universidad Carlos III de Madrid, Universidade Da Coruña, University of Coventry, University of Groningen, University of Leeds, University of Luxembourg, University of Porto, University of Surrey, University of the West of England, University of Zilina (UNIZA), Université de Toulouse III - Paul Sabatier, UPM Madrid, VUB Brussels MOBI, Warwick Manufacturing Group – University of Warwick,
Research providers	Aim Technologies, AIT, ALP.Lab, AVL List, BigTRI, Capgemini Engineering, CDV, CEA, CEDEX, CEIT, Cerema, CERTH, Cidaut, CNRS, CTAG, CVC, DLR, FEV, FMI, Fraunhofer, FZI, i2CAT, IBDiM, IBV, ICCS, IFPEN, IMEC, Instituto de Telecomunicações, Joanneum Research, KFV Austria Road Safety, LINKS Foundation, LIST, Łukasiewicz Research Network, LuxMobility, MOBY, Motor Transport Institute, NAITEC, RISE, Rupprecht Consult, Silicon Austria Labs, SINTEF, Tecnalia, TIS, TNO, TOI, Traficon, VEDECOM, Virtual Vehicle Research, Vicomtech, VTI,VTT
Public transport operators	Bahnen der Stadt Monheim
Mobility providers	Blees
Freight and logistics services	EINRIDE
Other services	Covéa, CSI S.P.A., DEKRA, IDIADA, Macif, Unipol
Countries	Austria BMK, French Ministry of Transport, Innovate UK, Netherlands Minienw, Spain Ministry for Transport, Transport Malta
National transport authorities	ASFINAG Austria, Austriatech, Autostrade per l'Italia SpA, Germany BASt, Highways England, Hungarian Public Roads, Netherlands RDW, Neth- erlands Rijkswaterstaat, Norwegian Public Roads Administration, Swedish Transport Agency, TRAFICOM Finland, Trafikverket Sweden, Transport Infrastructure Ireland, Transport Scotland, Vejdirektoratet Danish NRA
Local and regional authorities	ACCIÓ – Catalonia Trade & Investment Agency, Flemish Agency for Roads and Traffic, Forum Virium Helsinki, Gothenburg, Helmond, Ile-de-France Mobilités, Oxfordshire County Council, Provincie Noord-Brabant, TheCityofGdansk,Transportfor AthensOASA
Representative bodies	5GAA, ACEM, ALICE, ANEC, CAR 2 CAR Communication Consortium, CEDR, CLEPA, CONEBI, EARPA, ECTRI, EFA, EIT Urban Mobility, EPoSS, ERF, ERTICO, EUCAR, FEHRL, IRU, FIA, PAVE Europe, POLIS, SAE Group Europe, TISA, UITP
Platforms and clusters	ACS Slovenia, Bavarian Research Alliance, CIAC, Cluster Mobility & Logistics, CzeCCAM, Drive Sweden, FMC Ireland, French Automotive & Mobility Network, ICOOR Italy, ITS Norway, Kemin Digipolis Oy, NAAEV, PIARC Italy, SERNAUTOSpain, TechworksHub, Zone Cluster Hungary

4.2 Steps taken for the development of the SRIA

Advancing CCAM is a multi-stakeholders effort (see Figure 2: Sectors and types of stakeholders contributing to the Partnership and to the SRIA). When developing the SRIA, an open and transparent process was applied, involving public and private stakeholders across industries and value chains. Since CCAM is a new European Partnership under Horizon Europe, with no existing legal entity gathering yet the stakeholders, the consultation process was fully open, not based on membership, allowing any entity willing to contribute to do so. By the end of June 2020, more than 200 companies, organisations and associations expressed their interest to be part of this CCAM stakeholder community, and got involved in the co-design of the SRIA (see the following table). In this process, all stakeholder groups shown in Figure 2: Sectors and types of stakeholders contributing to the Partnership and to the SRIA provided an active contribution.

This chapter details the result of their work.

The CCAM SRIA builds upon the work done by Working Group 1 of the CCAM Single Platform[21]. This Expert Group was launched by the European Commission in June 2019 to provide advice and support

21 Expert group on cooperative, connected, automated and autonomous mobility, https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.group-Detail&groupID=3657

Industry
- Automotive industry, including supply chain
- ITS solutions, telecom providers, connectivity
- Data handling and storage industry, ...

Representative bodies
- Road users
- Stakeholder associations
- Road safety, society, the environment, ...

Public authorities & road operators
- Cities and regions
- Transport authorities, road authorities and operators
- Member States

Regulatory bodies
– National, European and international

Mobility & logistic services
- Public transport providers
- Mobility and logistics service providers
- Insurance, maintenance, ...

Research
- Universities
- Public research institutes
- Private research institutes

Figure 2: Sectors and types of stakeholders contributing to the Partnership and to the SRIA

to the Commission in the field of testing and pre-deployment activities for CCAM. Working Group 1, named "Develop an EU agenda for research and pre-deployment of Safe and Automated Road Transport", gathered representatives of all relevant CCAM stakeholders, including Member States. WG 1 drafted an agenda in a joint and interactive way, and provided an initial set of recommendations for future research and for related pre-deployment areas, based on member's inputs. The results of this WG were the starting point for the CCAM Partnership proposal and later the SRIA. Additional input from other existing multi-stakeholder roadmaps was used:

- the Strategic Transport Research and Innovation Agenda (STRIA) Roadmap on Connected and Automated Transport[22]: the 2019 STRIA report was prepared under the initiative of the European Commission to jointly develop a research and innovation roadmap for Connected and Automated Transport (CAT). It builds further on the previous STRIA roadmap published in 2017. The content of the document is mainly based on the contribution of experts of different stakeholder groups from industry, academia and national authorities.

- the CAD roadmap[23] (2019) of the Working Group on Connectivity and Automated Driving of the European platform ERTRAC[24], and recommendations on systems and technologies for interconnected logistics by the ALICE[25] platform.

- the results of the EU-funded Coordination and Support Actions CARTRE[26], ARCADE27[27] and SCOUT[28], which all are or were active in the field of coordination and consensus-building across stakeholders for sound and harmonised deployment of Connected, Cooperative and Automated Driving.

22 STRIA Roadmap on Connected and Automated Transport (CAT) Road, Rail and Waterborne, December 2020, https://trimis.ec.europa.eu/sites/default/files/2021-01/stria_cat_factsheet_2020.pdf

23 ERTRAC Connected Automated Driving Roadmap, 8.03.2019, https://www.ertrac.org/uploads/documentsearch/id57/ERTRAC-CAD-Roadmap-2019.pdf

24 ERTRAC is the European Road Transport Research Advisory Council. It is the European technology platform which brings together road transport stakeholders to develop a common vision for road transport research in Europe. ERTRAC activities are mainly performed in Working Groups, including the one on Connectivity and Automated Driving.

25 ALICE is the European Technology Platform: Alliance for Logistics Innovation through Collaboration in Europe. The work is performed in 5 Thematic Groups, who jointly drafted the Roadmap towards zero emission Logistics 2050 which was used in drafting the SRIA.

26 CARTRE Grant agreement ID: 724086, https://cordis.europa.eu/project/id/724086

27 ARCADE Grant agreement ID: 824251, https://cordis.europa.eu/project/id/824251

28 SCOUT Grant agreement ID: 713843, https://cordis.europa.eu/project/id/713843

The following steps explain the CCAM SRIA co-creation process from January 2020 until finalisation:

1. Initiation of the Partnership Proposal drafting team, following the request for such a group expressed by EC representatives in the CCAM Single Platform WG 1 meeting, on 27th January 2020. The drafting team consisted of a wide range of European associations representing the different CCAM stakeholders.
2. Combination of inputs from recent strategic R&I recommendations, during the period November 2019 – February 2020, also including recent work by the CCAM Platform WG1.
3. Discussing aim, ambitions, vision and main R&I areas in a first Stakeholder workshop, on February 17th 2020, in Brussels, with about 140 participants. Interests of participants to contribute to the Partnership were collected at this occasion.
4. Publication of draft Proposal and online consultation to collect feedback, in mid-March 2020: with over 90 detailed responses received, brought in by various stakeholders across the value chain.
5. Final draft of Partnership Proposal sent to European Commission services on 13 April 2020 (with a revised version published on EC website on 13 May 2020[29]).
6. In April 2020, the SRIA preparation started as fully transparent and open process, allowing all interested stakeholders to contribute to the definition of the vision, objectives and R&I priorities in seven CCAM Clusters (see Chapter 7).
7. Presentation, exchange and discussion with the CCAM Platform WG 1 experts on the Clusters, R&I actions and priorities, in the WG 1 meeting of May 4th.
8. From May 18th to 20th 2020: stakeholders involvement through a series of 7 open online workshops, specifically to validate the orientations of the SRIA content. In these meetings, the current state of the art, the ambitions and the steps to be taken were outlined, discussed and sharpened. With around 70 participants per session and a dynamic interaction, followed-up by email exchanges, ample and in-depth knowledge and explanations were gathered.
9. On June 3rd 2020, a dedicated meeting was organised to inform Member States representatives from respective Ministries on the progress of the CCAM Partnership preparation and SRIA drafting, and in particular on the willingness to set up a Member States Advisory Board within the Partnership governance in order to ensure a regular consultation of national representatives.
10. Distribution of draft SRIA content to stakeholders mid-June, and from June 16th to 18th, second series of 7 open online workshops, to discuss in detail the R&I actions and validate them with the stakeholders.
11. In July, the draft SRIA was published online and distributed to the stakeholders.
12. From September 17th to 28th, a public consultation was organised over the R&I priorities proposed for the first Work Programme 2021-2022 of the Partnership, with circulation of a draft and collection of input.
13. In September and October, the new CCAM Association that will support the Partnership activities was developed by the drafting team, gathering the views of all the different sectors to be represented. On November 5th, the call for membership to join this new association was released to the CCAM stakeholders, with distribution of the statutes and explanatory information.

29 Draft proposal for a European Partnership under Horizon Europe Connected, Cooperative and Automated Mobility (CCAM) Version 13 May 2020, https://ec.europa.eu/info/sites/default/files/research_and_innovation/funding/documents/ec_rtd_he-partnerships-connected-and-automated-driving-ccam.pdf

14. On November 23rd, an Information Day on CCAM was organised, to present to the public the objectives of the Partnership, collect opinions about the SRIA, and inform about the new association. More than 150 participants joined this Information Day. The draft SRIA and the call to join the new association were distributed again at this occasion. The event was registered and posted online, so the information stays available publicly.

The CCAM SRIA evolved through these stages and it received plenty of input and feasibility checks from key stakeholders (all of these are included in Table 2: Stakeholders involved in the CCAM SRIA development) in a wide variety of technology areas.

Table 2: Stakeholders involved in the CCAM SRIA development

CCAM stakeholders contributing to the Partnership SRIA development	
Research providers	AVL, AIT, Bast, CDV, CNRS, CEA, CEIT, Cerema, CERTH/HIT, Cidaut, CTAG, DLR, Eurecat, Everis, FEV, fka, FMI, Fraunhofer, I2CAT, ICCS, ICOOR, IDIADA, IFPEN, IMEC, INDRA, JRC, KTI, Lero, LINKS Foundation, Nervtech, Ricardo, RINA, RISE, SAFER, SINTEF, Tecnalia, TNO, TOI, Vicomtech, VTI, VTT
Universities	Aachen, Bari, Bordeaux, Budapest, Chalmers, Cork, Delft, Deusto, DTU, Dublin, Eiffel, Eindhoven, Florence, Galway, Gothenburg, Istanbul, Leeds, Leuven, Ljubljana, Madrid, Maynooth, Metropolia, Milano, Modena, Mondragon, Newcastle, Paris, Poznan, Prague, Sligo, Surrey, Thessaloniki, Turino, Upper Austria, Belfort-Montbéliard, Valencia, Warsaw, Zilina
Automotive	Akka, Alstom, Altran, BMW Group, Bosch, Bridgestone, CAFA Tech, Continental, DAF Trucks, Elaphe, Eminko, Eurocybcar, Farplas, Faurecia, FCA, Ford, GM, Hidria, Irizar, JLR, LAB France, Michelin, Mobivia, Navya, Pirelli, Reflective, Renault, Tofas, Valeo, Volkswagen, Volvo Group, Yamaha
ITS	Bestmile, Dynniq, HERE, Kapsch, LIT Transit, MAP TM, Mobilits, NNG, OmniOpti, PTV Group, Swarco, TomTom, TTS Italia, Trust-IT Services, Ubiwhere, YoGoKo
Telecom/IT	ELMOS, Ericsson, EVERIS, Huawei, Intel, NXP
Infrastructure	Abertis, Asfinag, Sanef, Vinci
Freight & logistics services and users	ALICE, Colruyt Group, Gebruder Weiss, Einride, IDIT, Procter & Gamble
Countries	Austria, Belgium, Czech Republic, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Spain, Sweden, UK
Regions, cities and public transport operators	Brussels, Catalunya, Flanders, Gothenburg, Helmond, Paris/Ile-de-France, Madrid, Rotterdam, Stuttgart, Usti, Tampere, Vienna, Wallonia
Representative bodies:	ACEA, ACEM, ALICE, AMICE, ANEC, C2C-CC, CEDR, CLEPA, CONEBI, EAPA, EARPA, ECTRI, EFA, EPoSS, ERF, ERTICO, ETNO, ETRMA, EUCAR, Eurocities, EuroRap, FEHRL, FEMA, FIA, FIGIEFA, GSMA, IRU, POLIS, UITP, 5GAA
Technology clusters and test centres, etc.	AV Living Lab, AIPSS, Aurora Snowbox, Austriatech, CARA, Catapult, Drive Sweden, FMCI, Lindholmen, Moveo, Pole MEDEE, PTCarrereta, ACS Slovenia, Business Tampere, Vedecom, VDI-VDE-IT, Zalazone, Zenzic

The stakeholders listed in Table 1 became CCAM Association members. Most of them participated in the different consultation steps of the SRIA development. The good discussions, in particular in the series of workshops held in May and June 2020 helped defining needed R&I actions for the SRIA. More than 400 experts contributed to these stakeholder workshops, demonstrating the availability of a strong expertise in all the research fields addressed by the Partnership.

The subsequent steps outline the collaborative process through which the CCAM SRIA update was meticulously crafted from January 2023 to its completion:

- In December 2022, the European Commission requested the reopening of the CCAM SRIA, aiming to incorporate any recent developments that could impact the document's content.
- A pivotal workshop took place on January 18th in Brussels, organised for the CCAM Partnership Delegation. During this gathering, sections requiring review were identified and discussed.
- Throughout March, the CCAM Association embarked on a comprehensive consultation process with its members. This initiative commenced with the CCAM Multicluster meeting exclusively for members on March 9th, 2023, in Brussels, drawing a participation of 125 esteemed individuals.
- May marked a significant phase of public engagement, beginning with the EUCAD2023 conference held on May 3rd-4th, 2023. This event, attended by a remarkable 650 participants, marked the commencement of a broad public consultation.
- Member States were granted a dedicated consultation platform during the CCAM SRG meeting on May 16th, 2023, with representation from 21 countries contributing to the dialogue.
- The European Commission's input was sought during the summer of 2023, further enriching the collaborative refinement of the document.

In the CCAM SRIA, updated in the course of 2023, except for the regulatory actions and standardisation updates in the field of CCAM, a new sub-chapter titled "Other recent developments" has been introduced to account for ongoing changes in the field. This section encapsulates a range of important developments that have implications for the CCAM Partnership's objectives and aspirations.

The addition of the "Other recent developments" sub-chapter reflects a dynamic landscape shaping the CCAM field. The expansion encompasses diverse elements impacting the CCAM Partnership's trajectory, encompassing both synergies and challenges. Several overarching trends stand out:

- Evolving societal dynamics
- Shifting work and mobility patterns
- Environmental and equitable mobility focus
- CCAM technologies progress
- Enabling technologies and data sharing updates
- Hurdles and learning opportunities
- Synergies and sustainable transitions

Incorporating these recent developments into the CCAM SRIA, the CCAM Partnership remains dedicated to European leadership in safe and sustainable road transport through automation. The imperative to address energy, climate, and mobility challenges calls for a systems-oriented approach, advocating a synergy between CCAM and clean mobility solutions. By adapting to societal needs and industry shifts, the CCAM Partnership is ready to lead CCAM in Europe in the ever-changing global landscape.

The Partnership is open for stakeholders to join from the start and during the Partnership duration. Any entity involved in R&I on CCAM and willing to commit and contribute to the CCAM SRIA will be welcomed to join the stakeholder network.

5. Policy context

5.1 Policy aspects

European Partnerships are key implementation tools addressing global challenges and contributing significantly to achieving the EU's political priorities. The transformational change in mobility will have a huge impact on all road, traffic and driving situations. In addition, advancing digitalisation, extreme growth in (big) data availability and increasing connectivity for users are shaping new business models in transport, modifying the future mobility needs and perceptions in society. With the expected impacts, the CCAM Partnership will contribute to the UN Sustainable Development Goals[30] (SDG), specifically to

- **SDG 3** (Ensure healthy lives and promote well-being for all at all ages)

  e.g. by providing safer, more sustainable and efficient mobility thus contributing to reducing the number of deaths from road traffic accidents and reducing automotive emissions for improved air quality and health;

- **SDG 9** (Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation)

  e.g. by funding research and innovation following a strategic agenda for significant economic impact, providing opportunities for new products and services in an area of utmost importance to the future competitiveness of the European transport industry;

- **SDG 11** (Make cities and human settlements inclusive, safe, resilient and sustainable)

  e.g. by providing safe, affordable, accessible and sustainable transport systems for all people including persons in vulnerable situations, and by drastically reducing the number of accidents caused by human error and thus increasing safety for all road users, including unprotected ones;

- **SDG 13** (Take urgent action to combat climate change and its impacts)

  e.g. by optimising infrastructure capacity usage, reducing congestion, smoothening traffic flow, avoiding unnecessary trips and thus reducing CO_2 emissions.

In relation to SDG 11, the CCAM Partnership is contributing to the EU Mission on Climate-Neutral and Smart Cities[31]. The aims of this Mission are to deliver 100 climate-neutral and smart cities by 2030 and to ensure that these cities act as experimentation and innovation hubs to enable all European cities to follow suit by 2050. This Mission is central to the overall European Green Deal[32], a comprehensive and ambitious strategy package for Europe to become the world's first climate- neutral continent by 2050. An example of the Partnership's contribution to the Cities Mission is the 2023 call on co-designed smart systems and services for user-centred shared zero-emission mobility of people and freight in urban areas. The Partnership will maintain this involvement.

30 Take Action for the Sustainable Development Goals, https://www.un.org/sustainabledevelopment/sustainable-development-goals/

31 European Missions. 100 Climate-Neutral and Smart Cities by 2030. Implementation Plan: https://research-and-innovation.ec.europa.eu/document/download/d2eb2069-3b4a-4015-9801-7daab749d31b_en?filename=cities_mission_implementation_plan.pdf.

32 The European Green Deal, COM(2019) 640 final, Brussels, 11.12.2019, https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf

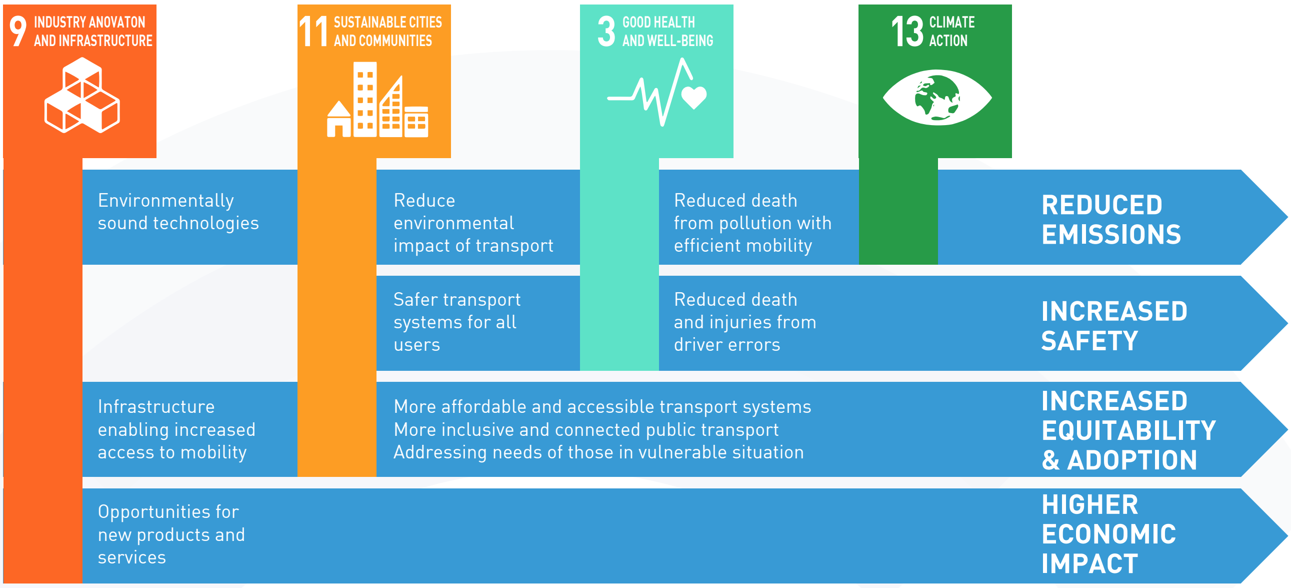


Figure 3: CCAM contributing to UN SDGs

For mobility, this includes leveraging the digitalisation of transport with smart and automated mobility systems in pursuing the ambitious sustainability objectives of the European Green Deal. Shared mobility services well integrated with public transport will accelerate the shift to sustainable and smart mobility with a reduced carbon footprint. Thus, CCAM will contribute to further reduce congestion, air pollution and CO_2 emissions with smart traffic management, reducing peak usage of road infrastructure, which also leads to a decrease in land use for road infrastructure in line with a resource-efficient economy. Leaving no one behind in this transformation is another key element of the Green Deal, which the CCAM Partnership will address directly by increasing the inclusiveness of road transport.

Since human error is a major factor in more than 90% of road crashes, CCAM through its anticipated transformation of the vehicle fleet, infrastructure use and transport system management has the potential to drastically improve the safety of the road transport system. It will contribute to moving closer to having zero fatalities on European roads by 2050, which was set as a goal already in the EC Transport White Paper of 2011[33] and confirmed by the 3rd Mobility Package of May 2018[34]. The latter extended this goal to serious injuries and thus implies moving towards Vision Zero, a road transport system in which no one is killed or severely injured. The commitment to addressing the trauma caused by road crashes was further reaffirmed by the Commission in the road safety policy framework of 2020[35]. This document identifies the potential risks associated with automated vehicles operating in mixed traffic. It also affirms the need to harmonise HMI in order that all drivers and users can interact with vehicles without compromising safety. The CCAM partnership will bring Europe a step closer Vision Zero by carrying out R&D targeted at delivering automation and connectivity to deliver a high level of safety.

Both Vision Zero and the European Green Deal are reflected in the expected impacts of the CCAM Partnership: drastically improving the safety and security of the transport system and meeting societal needs for mobility while reducing environmental impacts and strengthening our economy. At the same time, there are European policy initiatives that directly address the need for automated mobility.

33 Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, COM(2011) 144 final, Brussels, 28.03.2011, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0144&from=EN

34 Europe on the move – Sustainable mobility for Europe: safe, connected, and clean, COM(2018) 293 final, Brussels, 17.05.2018, https://eur-lex.europa.eu/resource.html?uri=cellar:0e8b694e-59b5-11e8-ab41-01aa75ed71a1.0003.02/DOC_1&format=PDF

35 3EU road safety policy framework 2021-2030 – Next steps towards 'Vision Zero'. DG MOVE, 2020. https://op.europa.eu/en/publication-detail/-/publication/d7ee4b58-4bc5-11ea-8aa5-01aa75ed71a1

In the Communication "On the road to automated mobility: An EU strategy for mobility of the future"[36] the European Commission lays down its vision, objectives and actions for an accelerated deployment of CCAM with the ambition of making Europe a world leader in this domain. This vision is further strengthened in the communication "The Smart and Sustainable Mobility Strategy"[37].

In line with this ambition, maintaining and extending industrial leadership for new jobs and economic growth all over Europe is another expected impact of the CCAM partnership. The communication highlights Use Cases of CCAM that will be particularly relevant from the public policy perspective in the next decade. Intended actions in the areas of technology development, regulation, certification and impact assessment are outlined as well as the establishment of a partnership for CCAM, as detailed in this SRIA.

The Declaration of Amsterdam[38] highlighted the willingness of EU Member States to cooperate and agree on joint goals and actions to facilitate the introduction of connected and automated driving on European roads. Its objective is to prevent that a patchwork of regulations arises within the EU, which would be an obstacle for both industry and road users. It means that EU Member States must work on compatibility e.g. of safety requirements, liability issues, communication systems and services, in order to facilitate future market deployment, and therefore promote European competitiveness in this field. The Declaration of Amsterdam also supports the adoption of a "learning by experience" approach, "including, where possible, cross-border cooperation, sharing and expanding knowledge on connected and automated driving". The EU Member States agreed to foster a high-level structural dialogue to monitor and guide actions from the declaration and give recommendations to EC while facilitating the exchange of best practice between them. The conclusions of the 4th High Level Meeting on Connected Automated Driving[39] in October 2020 elaborated further on the need for more harmonisation to ease the testing of automated vehicles in different countries and to improve learning from the experiences of testing, recognise the importance of having a central European database collecting relevant information on CCAM research, testing, piloting and deployment activities and its results in Europe and beyond.

The CCAM Partnership will foster such cooperation and harmonisation by setting strategic objectives in terms of agreed safety standards for automated driving systems (ADS), improved synergies between public and private investment plans to advance vehicle and infrastructure technologies, and by providing a long-term coordination framework for R&I and large-scale testing activities. To further improve the exchange of experiences and foster cooperation, the Partnership will support the expansion and dissemination of the knowledge base on CCAM solutions, stakeholders, R&I programmes and projects, and testing activities.

The final report of the high-level group on the competitiveness and sustainable growth of the automotive industry in the European Union (GEAR 2030)[40] emphasises among others the medium and long-term recommendations for automated and connected vehicles. It references amongst others the Declaration of Amsterdam and highlights strategic planning and public private partnerships as suitable tools to take the full benefit of large-scale testing and research programmes both at EU and at Member State level. More specifically, the report calls for a new approach on vehicle approval and for the assessment of the long-term impacts of increasingly automated and connected road transport, in particular, on jobs and ethical issues to ensure social acceptance. All these recommendations will be directly addressed

36 On the road to automated mobility: An EU strategy for mobility of the future, COM(2018) 283 final, Brussels, 17.05.2018, https://ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/com20180283_en.pdf

37 Cf. Footnote 17.

38 Declaration of Amsterdam – Cooperation in the field of connected and automated driving, 14.04.2016, https://www.rijksoverheid.nl/documenten/rapporten/2016/04/29/declaration-of-amsterdam-cooperation-in-the-field-of-connected-and-automated-driving

39 High-level meeting on connected and automated driving aims at strengthening cooperation, 7.10.2020, https://www.lvm.fi/en/-/high-level-meeting-on-connected-and-automated-driving-aims-at-strengthening-cooperation-1234725

40 GEAR 2030 – Final Report 2017, DG GROW, October 2017, https://ec.europa.eu/growth/content/high-level-group-gear-2030-report-on-automotive-competitiveness-and-sustainability_en

by clustered R&I activities of the CCAM Partnership on large-scale demonstrations, validation and on societal aspects and people needs with the expected impact of strengthening leadership in all technological and societal aspects of CCAM through targeted knowledge and capacity building.

It is evident that digitalisation and particularly technologies such as ITS-G5, 5G networks, AI, IoT and electronic components and systems will play a major role in the development of CCAM (see chapter 8 for the digital-domain partnership description). With new entrants from the digitalisation industry in the mobility market the market mechanisms could change dramatically and force established industrial actors to undertake radical changes with all the consequences on working force, investment and business models. Keeping a leading edge in innovation is mandatory to sustain a long-term economic benefit in this domain. This will be essential for staying ahead of e.g. the USA and China as Europe's main competitors and likewise most important external markets for CCAM.

The European Commission has published the first-ever legal framework for regulating AI uses and risks. The regulatory proposal aims to provide AI developers, deployers and users with clear requirements and obligations regarding specific uses of AI. The proposal is part of a wider AI package, which also includes the updated Coordinated Plan on AI.

The AI Act (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52021PC0206) proposes a set of risk-based harmonised rules for dealing with AI based systems such as automated mobility. The 'risk-based approach' consists of the use of risk levels as thresholds for specific development, testing and certification requirements.

The EU is a pioneer in proposing a regulation on harmonised rules on fair access to and use of data. The Data Governance Regulation proposed in November 2020 was the first deliverable of the European strategy for data. The current initiative covers different types of data intermediaries, handling both personal and non-personal data. This includes the General Data Protection Regulation (GDPR)[41] and ePrivacy Directive[42] which set a solid and trusted legal framework for the protection of personal data and a standard for the world. The Data Governance Regulation complements the Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information (Open Data Directive)[43]. While the Data Governance Regulation creates the processes and structures to facilitate data, the Data Act[44] clarifies who can create value from data and under which conditions. The Data Act, adopted by the Commission on 23 February 2022, includes measures to allow users of connected devices to gain access to data generated by them, which is often exclusively harvested by manufacturers; and to share such data with third parties to provide aftermarket or other data-driven innovative services.

The transport and mobility domain has its own mechanism for data sharing and specifications through the ITS Directive at the EU level. With the changes proposed for the ITS Directive by the European Commission on 14th December 2021, new and emerging challenges are tackled in the deployment of ITS services, a key component for CCAM deployment. The revised ITS Directive, seeks to resolve problems stemming from the lack of interoperability and continuity of the existing applications and services and aims to ensure effective concertation and cooperation among stakeholders[45]. The revision aims to increase the data availability by mandating the collection of crucial transport data and the provision of essential services such as real-time information services for safety and sustainable travelling choices. It will better cover emerging services across the EU, such as multimodal information, booking and ticketing services (e.g., apps to find and book journeys that combine public transport, shared car or bike services) and communication between vehicles and infrastructure (Cooperative-ITS). This would

41 General Data Protection Regulation (GDPR): https://eur-lex.europa.eu/eli/reg/2016/679/oj.

42 ePrivacy Directive: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32002L0058.

43 Open Data Directive: https://eur-lex.europa.eu/legal-content/EN/TXT/OJ%20L%20172,%2026.6.2019,%20p.%2056%E2%80%9383.

44 Data Act: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A68%3AFIN.

45 Revised ITS Directive: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302661

greatly support efforts in building digital road infrastructure in Europe to enable CCAM services. In September 2020, the EC published a report from an independent expert group on "Ethics of Connected and Automated Vehicles"[46]. In this report, the authors propose 20 recommendations "promoting a safe and responsible transition to connected and automated vehicles". The relevant recommendations addressing R&I actions have been considered in the CCAM SRIA to support stakeholders in the systematic inclusion of ethical considerations in the design, development and deployment of CCAM systems and services.

To fully capture and address ethical issues raised by CCAM for the long-term, close collaboration with other R&I initiatives and programmes will have to be stimulated. For example, the regular assessment of a joint portfolio of R&I projects across Horizon Europe referring to the ethical issues identified by the expert report will be necessary to detect gaps and overlaps, but also to maximise synergies and promote ethics as a strategic objective in European R&I.

5.2 Regulatory actions

In 2016, the Global Forum for Road Traffic Safety (UNECE WP.1) amended the 1968 Vienna Convention on Road Traffic enabling automated systems to assist the driver in continuous vehicle control to operate in traffic.In addition, the 10 km/h limitation for autonomous systems was removed from UN Regulation No. 79[47]. In order to accelerate progress, the World Forum created a dedicated Working Party (WP) on Autonomous and Connected Vehicles (GRVA) in 2018.

In June 2020 the UN Regulation (R157) on uniform provisions concerning the approval of vehicles with regards to Automated Lane Keeping System (ALKS) was adopted by WP.29.[48] This Regulation was the first regulatory step for an automated driving system (as defined in ECE/TRANS/WP.29/1140) in traffic and it therefore provided innovative provisions aimed at addressing the complexity related to the evaluation of the system safety. It contains administrative and technical provisions for type approval including technical requirements, audit and reporting provisions as well as testing provisions. This timely action was an important first step in preparation of a more generic and long- lasting regulatory framework developed in the above-mentioned work on functional requirements and validation methods. The regulation, for passenger cars, permitted the installation and approval of ALKS that operates on a single lane on limited access roads at speeds of up to 60 km/h. In November 2021 the regulation was amended to cover heavy vehicles including trucks, buses and coaches [49]. In June 2022, it was further amended to permit the approval of ALKS with a maximum speed of 130 km/h and with capability to perform lane changes [50]. Thus driving under Level 3 automation is starting to become a reality.

On the EU side, the General Safety Regulation of 2019 gave the European Commission the authority to adopt harmonised rules and test procedures for the type-approval of vehicles with automated driving systems, including fully automated vehicles, and for the type-approval of those systems as separate technical units. In consequence, during 2022, the EU introduced a regulation (Commission Implementing Regulation (EU) 2022/1426) that, for the first time anywhere in the world, permitted the whole vehicle type-approval of fully automated vehicles (driverless vehicles with SAE Level 4 capabilities). These new provisions allow the introduction to the market, via the small series process, of driverless vehicles in the form of shuttles and taxis operating in defined areas of hub-to-hub systems designed and constructed for the carriage of passengers or goods on a predefined route or of

46 Ethics of Connected and Automated Vehicles, accessed on https://ec.europa.eu/info/news/new-recommendations-for-a-safe-and-ethi-cal-transition-to- wards-driverless-mobility-2020-sep-18_en

47 The World Forum for Harmonization of Vehicle Regulations, hosted by UNECE, is the intergovernmental platform that defines the technical requirements applied by the automotive sector worldwide.

48 UN Regulation on Automated Lane Keeping Systems is milestone for safe introduction of automated vehicles in traffic, 24.06.2020, https://www.unece.org/?id=54669

49 UN regulation on Automated Lane Keeping Systems (ALKS) extended to trucks, buses and coaches: https://unece.org/media/press/362551

50 UN Regulation extends automated driving up to 130 km/h in certain conditions: https://unece.org/sustainable-development/press/un-regula

automated functions available in dual mode vehicles for parking applications within predefined parking facilities. Thus they encourage new public and private deployment; they also lay the groundwork for full series approval in the future.

As a further development, the Automated and Connected Vehicle subgroup of the EU Working Group on Motor Vehicles (MVWG) has recently begun developing a Summary Report on Policy-related Topics that details a number of specific policy topics on type approval and on traffic rules that require further specification and, in many cases, also require further research. In particular, the Summary Report specifies the need for further research on the safe use of ADS as well as the need to specify what constitutes safe vehicle behaviour in the context of automated driving. The document refers to the need to coordinate with the CCAM Partnership. The R&D in CCAM can help provide answers to the policy questions and can also assist the regulators with knowledge on how to ensure safe use of ADS and the safe driving behaviour of automated vehicles.In parallel, UNECE has been developing a series of resolutions, pre-regulatory texts and regulations in the area of automated driving. In September 2018, WP.1. the Global Forum for Road Traffic Safety, adopted a resolution on the deployment of highly and fully automated vehicles in road traffic [51]. This resolution considered that it could be legal for an automated driving system to replace the human driver. Subsequently, WP.1 has started the process to amend the Vienna Convention of Road Traffic to the same end.

The same body, in September 2022, adopted a resolution on safety considerations for activities other than driving undertaken when an ADS is performing the dynamic driving task [52]. This resolution envisages that, provided the safety considerations for example on HMI are addressed, activities that are currently considered illegal could be permitted under Level 3 and Level 4 driving.

There has also been substantial progress at the international level on regulations and recommendation regarding vehicle technologies. In March 2021, UNECE WP.29 approved Regulation 155 on cyber security and the management system for cyber security [53]. This regulation establishes principles and processes to deliver cybersecurity at an organisational and individual vehicle level. In parallel, the informal working group on the Data Storage System for Automated Driving has been developing a specification of the data elements to be stored by an ADS, to be used for example in crash investigation.

Two informal working groups under GRVA have been focussed on the safety aspects of automated driving systems. The group on Functional Requirements for Automated and Autonomous Vehicles (FRAV) has been developing a set of safety requirements, for example on ADS performance of the dynamic driving task and on interaction with the user. In parallel, the informal working group on Validation Method for Automated Driving (VMAD) has been developing the test methods that type approval authorities could use to ensure that the various functional requirements have been met. VMAD issued the final draft of its master document New Assessment/Test Method for Automated Driving in January 2021 [54], and is continuing to develop its assessment methodologies. In the longer run, it is anticipated that the FRAV requirements and VMAD methods will be merged into a consolidated document that will become a regulation.

As regards usage of automated systems on the road, vehicle requirements, identification and registration, exemption legislation and procedures as well as road safety, traffic rules or driving licenses are both still regulated by EU and/or national standards. In this context, each country can

51 Resolution on the Deployment of Highly and Fully Automated Vehicles in Road Traffic: https://unece.org/transport/publications/resolution-deployment-highly-and-fully-automated-vehicles-road-traffic

52 Resolution on safety considerations for activities other than driving undertaken by drivers when automated driving systems issuing transition demands exercise dynamic control: https://unece.org/transport/publications/resolution-safety-considerations-activities-other-driving-undertaken-drivers

53 UN Regulation No. 155 - Cyber security and cyber security management system: https://unece.org/transport/documents/2021/03/standards/un-regulation-no-155-cyber-security-and-cyber-security

54 (VMAD) New assessment/test method for automated driving - Master Document (final draft): https://unece.org/documents/2021/01/informal-documents/vmad-new-assessmenttest-method-automated-driving-master

set its own specific regulatory framework for Automated Driving (AD) purposes. As a consequence, the current procedures for obtaining a testing permission varies a lot between countries. In some countries for example, an application form indicating several fulfilled requirements (e.g. safety standards, test driver training) or ministerial discussions (also involving other experts) are needed. In other countries a "simple" description of the test case, the roads to be used and the commitment to some safety/environment recommendations is required. In others, there are still no requirements defined. A harmonised European framework for testing on public roads would help to streamline the different national and local processes for obtaining testing permissions and thus facilitate mutual recognition of procedures across Member States.

Permits to test vehicles with automated driving systems on open roads is, however, just a first step towards the actual commercial deployment of such technologies. Even if automated driving systems are approved for use on European roads, there is still a need for counterpart national traffic laws to allow the human "driver" to disengage from the driving task and to perform non-driving related tasks. Currently, such laws are not widespread.

The CCAM Partnership will accelerate implementation and further enhance capabilities and value of CCAM solutions by providing early alignment between stakeholders on future regulations based on knowledge and scientific background from testing, demonstration and validation actions.

5.3 Standardisation

Given the multi-faceted nature of the systems and technologies involved, standardisation as it affects CCAM is both very broad and a fast-evolving area, requiring collaboration from industries, academia and public actors, involving different standardisation organisations both worldwide (e.g. ISO, ITU) and European (e.g. ETSI, CEN, CENELEC). Within the standards organisations there are relevant general technical committees as well as more specialised subgroups that are dedicated to particular aspects of CCAM. Awareness of the broader picture is a challenge but nevertheless very important as is also a dialogue between communities and committees. Standardisation is also a two-way route: CCAM needs to take advantage of standardisation achievements but also to contribute to the formulation of new standards based on the results of R&I.

It should also be noted that standards are not frozen. One of the most significant standards for CCAM, SAE J3016 Recommended Practice: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles, commonly known as the SAE Levels of Driving Automation, was originally issued in 2014. Since then, revised version have been issued in 2016, 2018 and 2021 with that last version also becoming an ISO standard as ISO/SAE DPAS 22736. It is understood that a further revision is currently being made by an ISO-SAE Joint Working Group. Such revisions may entail very significant changes.

5.4 Other recent developments

Recent developments are taken into account in the development of this Strategic Research and Innovation Agenda. Some recent developments are reinforcing the ambitions and objectives of the CCAM Partnership, others may add to the existing challenges to be addressed by the Partnership. These all are gathered in this section.

Overarching developments

Ongoing societal developments do call for a reality check on CCAM developments. Upscaling from pilot to living lab to full deployment is not yet effectuated, partially because the initial optimism on technological maturity is being evaluated in light of on-road experiences with CCAM solutions. Across Europe, a hybrid stage of both CCAM development and CCAM deployment can be seen, in which different SAE Levels of automation are included. Societal initiatives like the introduction of 15 Minute cities, including the growing momentum for car-lite cities, are challenging the development and implementation of CCAM enabled mobility. The contribution of CCAM to these developments should be clarified, in order to facilitate an effective CCAM industrial development. The need for this is shown by the collapse of some tech starters in this field. Apart from this, it is essential to develop a clear picture on the relation between advancing levels of CCAM implementation and labour force and employment, in line with needs indicated e.g. due to the trucking crisis due to severe driver shortages in US.

Originating from the Covid-19 pandemic, there is the longer-term increase in hybridisation of work and the changing work and travel patterns, which do challenge mobility service and technology providers. The pandemic also saw the acceleration of e-commerce, which has an impact on goods mobility. Large scale CCAM deployment needs to facilitate these mobility demands.

Furthermore, society is more and more asking for proof that CCAM contributes not only to improved safety and comfort, but also to decrease the environmental footprint of (road) mobility, taking into account a gradually increase in deployment rates. Furthermore, advanced approaches and tools are demanded, to avoid that the compute power needed for CCAM applications are nihilating any potential positive environmental impact, as well as an understanding of how this intermediate phase facilitates the longer term positive effects. CCAM's role in providing equitable mobility is being requested. These demands are further being stressed by the raised awareness of energy and resource scarcity.

CCAM related achievements

Since the initial discussions regarding the launch of the CCAM Partnership, and building further on e.g. the efforts of HE funded projects and their dissemination activities, a clear change in the general public awareness regarding vehicle automation is seen. Demonstrations and living labs have shown to be instrumental in raising this awareness and in facilitating discussions on benefits, risks, user acceptance, harmonisation and regulatory needs. The coherent approach towards further CCAM developments with a large group of various stakeholders, as advocated by the CCAM Partnership, is reflected in these discussions and in the strong role of European joint activities. This coherence is more and more putting European (research) CCAM industry at the international forefront. Hand in hand with these developments, it is seen that an increasing number of EU countries has a set of dedicated regulations in place, regarding CCAM -mostly- in on road testing activities. Further steps still are needed for CCAM beyond L3 on the road, in deployment. A harmonized European approach will be essential for broad implementation of the related technologies. National regulations need to be harmonised to facilitate the long-term increasing willingness with city authorities to engage in CCAM demos. This reinforces the opportunities for co-creation and larger scale living labs, with user engagement. Nevertheless, in order to capitalise on this, there is the need for the CCAM Partnership to provide clear guidance on the usefulness of CCAM in meeting societal targets and true needs of people, and how potential negative effects -such as energy consumption and costs – are counteracted for. At the same time, it will be important to prevent over-expectations and capture and share difficulties encountered.

Advancement of technology enablers

The advancement of various technologies is enabling the deployment of CCAM enabled mobility solutions. One instrument is, for example, the advancement of connectivity, with 5G implementation as main issue. The further developments in this field, including the (technological and societal) developments towards 6G and further on 7G will be essential for effective and efficient use of CCAM technologies. Reliable V2X communication, including V2V and V2I, based on 5-7G, are key requirements for CCAM. This is linked to the eminent need for further advancements in the CCAM Service space, which is based on amongst others accurate, available and up-to-date HD maps.

The advancements in the field of Artificial Intelligence (AI), edge computing, and integrated sensing and communication can to a large extent facilitate further developments of CCAM. Especially when using the opportunities offered by AI and edge computing to advance on the systems approach and systems optimisation, taking into account safety, comfort, transport efficiency and energy consumption, the uptake of CCAM enabled mobility solutions can largely be increased. It's important to stress here the fact that this development also is supported by the advancing focus on ethics, trustworthy and explainability of AI, human-technology interaction and integration topics and ultimately agreement on the process of releasing the technology for open road use, are essential for user acceptance. Trustworthiness is a fundamental aspect to be considered for integrated sensing and decision-making.

A key enabler and/or roadblock for CCAM is data sharing, across Europe and across industry actors. Steps are being made towards practical implementation, with HE funded projects like L3-Pilot and Hi-Drive as front runners. Member State openness and interactions are needed for the cross-Europe approaches. Work is ongoing to determine, what information sharing is absolutely needed, to ensure data-sharing-for-a-purpose. Steps are also being made with the further advancements of the European Mobility Data Space.

Data privacy, protection and governance as well as developing an joint approach how to address cyber threats will play an important role in the future of CCAM. First HE funded projects like SELFY address this. This relates to the increasing call for experience in white hacking and GPS jamming, to increase CCAM resilience.

Impediments

Several recent (societal) developments may bring up some roadblocks for CCAM implementation. The ongoing and increasing inflation, all over Europe, and the decreasing R&I funds are of major concern. Furthermore, the appetite for international collaboration is seen to be decreasing due to e.g. the decreasing funding rates (60% vs originally 70% for Innovation Actions). The political situation -the war in Ukraine-, tightening tendencies towards de-coupling and the energy crisis are further increasing the pressure on international collaboration. Besides this, the number of bad examples of AVs on public roads is gradually increasing, with some Tesla autopilot fatal accidents and failures as most eye catching. These examples decrease the level of user acceptance and the willingness of public transport operators to use CCAM technologies in mixed traffic. On the other hand, there is the too often overlooked learning potential from these cases, for the stakeholders.

The tension between lack of regulation and overregulation is a continuous challenge, potentially blocking fast CCAM implementation. An example here is the lack of coherency and central actions in the field of access to in-vehicle data.

Opportunities for CCAM developments and implementation

Some of the above mentioned points can help to boost the effect of the full chain from R&I up to implementation of CCAM enabled technologies. In most cases this has to be done alongside with several other developments. The raised awareness of urgent needs towards climate protection and expected resource constraints urge the mobility sector to transition towards a sustainable sector. Sustainable sources of energy are to be included in mobility. Advances in e.g. enabling technologies such as AI can facilitate this, by having a more systemic approach and making the change possible to establish a solid link between mobility and energy grid, and management of energy, as well as to the IT sector. This is also reflected by the fact that transport challenges are more and more often combined with challenges in the fields of energy and climate, both nationally and at EU level, like in the Green Deal. For CCAM, this is demonstrated by e.g. Horizon Europe's topic MISS-2023-CIT-01-01 where the Cities Mission and the partnerships CCAM and 2Zero are joining forces.

The joint European approach enables faster uptake, and helps to ensure creating a viable value chain with several sectors cooperating. This needs to be agile, to incorporate the increasing use of micro-mobility means, especially in (sub)urban areas. It needs to incorporate as well the growing demand for cities to be directors of their overall mobility (eco)system. This includes for instance the wide-spreading use of lower speed limits in cities, which in many cases is decreasing from 50 kph to 30 kph. This could facilitate the uptake of CCAM technologies in mixed traffic, as in many regions, shuttles and highly automated vehicles have a maximum speed limited below 50 kph in urban applications. Furthermore, the cities as directors of their mobility systems are asking for services and solutions with specific functionalities matching their specific city requirements; automated functions can be tailored for this, especially when they are based on AI solutions. For public transport, many regions are facing a lack of trained staff and drivers. CCAM enabled solutions can address this, once ready for larger scale deployment. Yet, in doing so, it needs to be ensured that the labour force is adequately trained for appropriate roles and availability to address the needs of the users and the overall mobility system. A practical example in which this need can be seen is the introduction of Mobility as a Service (MaaS), for which enhanced organisational and digital skills and a trained workforce are essential.

CCAM Partnership approach reflecting recent developments

The recent developments as described before, do stress the relevance of the CCAM Partnership's vision: European leadership in safe and sustainable road transport through automation, and thus the autonomy of EU with regards to e.g. US and China.

In the upcoming SRIA period, an increasing focus is needed on the synergies with clean mobility solutions and CCAM for sustainability. This is essential to contribute to the EU vision to become energy independent. This can only be done by following a systems approach, considering societal challenges in climate, energy and mobility, and by following an approach of system innovation taking into account CCAM developments on infrastructure, vehicle, ICT, logistics and services. The desire for energy independence may also bring along the need for sustainable mobility behavioral changes, even apart from previously mentioned changes in mobility patterns caused by Covid-19. This will also include the increased use of shared means of transport, supported by CCAM technologies, both for urban and rural applications, and solutions and services have to ensure equitable access to personal mobility and transport of goods. Working with specific use cases can facilitate these developments, addressing real world needs and requirements.

6. Vision and challenges

6.1 CCAM Partnership Vision

The vision of the CCAM Partnership for the next 10 years is to make Europe a world leader in the development and deployment of connected and automated mobility and logistics services and systems and thereby provide a significant contribution to European leadership in safe and sustainable road transport.

Within this period, CCAM shall foster and support new mobility concepts, shifting design and development from a driver-centred to mobility-user oriented approach, providing viable alternatives for private vehicle ownership while increasing inclusiveness of mobility. CCAM solutions will be integrated in the whole transport system, accompanied by the right support measures of the public sector (e.g. incentives, legal frameworks) to fully exploit the potential benefits of CCAM and minimise potential adverse effects, such as increasingly congested traffic or new risks in mixed traffic environments.

Automated vehicles will increasingly allow the transfer of the control tasks from the driver to the vehicle system, and the driver may finally be obsolete, even in particularly challenging and complex traffic environments. This implies a step change in the safety concept of road transport and poses big challenges in terms of robustness and reliability.

The vehicles and other road users, including vulnerable ones such as pedestrians and cyclists, will benefit from increased connectivity with vehicles and the infrastructure. This connectivity will allow them to better coordinate their manoeuvres, making use of active infrastructure support and enabling smart traffic and fleet management for improved throughput and increased safety. Shared, automated mobility and freight services will become widely available, providing seamless door- to-door mobility for people and goods including fully autonomous last mile deliveries, leading to healthier, safer, more accessible, greener, cost-effective, demand-responsive and more sustainable transport everywhere.

In short, the CCAM Partnership Vision is to ensure

> European leadership in safe and sustainable road transport through automation.

6.2 Challenges to deploy CCAM systems and services

For the Partnership to achieve its vision and expected impacts, a multitude of complex challenges need to be addressed and solved at **societal, human, technical, regulatory, economic and operational level**. These challenges are categorised and summarised as problem drivers (PD).

> Insufficient demand as society does not yet understand the potential benefits of CCAM enabled mobility. The long-term implications, benefits and impacts of integrating CCAM solutions into the mobility system are not sufficiently examined. (PD1)

Society does not yet demand a transition to CCAM enabled mobility since the potential implications and benefits (such as enhanced safety or lower environmental impacts) of the integration of CCAM solutions into the mobility system have yet to be demonstrated, and they are not well understood. Consequently, there is a lack of awareness, acceptance and adoption by citizens and policy makers.

Changing public opinion requires evidence that CCAM systems are safe and that they are useful. Within this context, the partnership must prove that integrated CCAM solutions offer societal benefits with perceived advantages for each end-user and that CCAM solutions integrated in the mobility system are safe.

One main challenge will be to provide shared, on-demand and personalised transportation available to all, contributing to the inclusiveness of future transport systems. Automated taxi/pods/ shuttles/ buses, and shared vehicles in general, will be new options made available to help fulfil this mission which should be demonstrated in urban, peri-urban and rural areas. Essential will be the development of CCAM solutions and mobility services complementing existing public transport. that are attractive for service providers, operators and -users of automated and shared vehicles. In addition, business models and business cases for automated and shared vehicles need to be developed, as well as interoperability and integration with public transport. To support these future CCAM solutions infrastructure research, innovations and investments are also needed. The intended services need to be well integrated with urban planning and urban economics, with appropriate governance models in order to ensure a high degree of acceptance among all stakeholders.

Safety of CCAM needs to be ensured, and the main challenge for safety validation is that depending on the operational design domain (ODD[55]) many different driving situations and complex scenarios must be tested and validated. Fortunately, during the last years, significant progress has been made to define methodologies for the effective validation of connected and cooperative automated driving systems. All the regulation mentioned in section 3.2 are developed towards the adoption of a multi-pillar approach in which physical testing (both in proving grounds and real roads), virtual testing, the audit of the safety management system put in place by the manufacturer and a proper in-service monitoring and reporting are jointly used to ensure the safety of automated driving systems. Tools that are needed to follow this multi-pillar approach efficiently have to be (further) developed and validation scenarios defined cooperatively by European actors to avoid fragmentation and the duplication of efforts in a highly competitive global market. Moreover, validation methodologies need to be further developed in parallel to the emergence of new technology and related national research efforts be coordinated on the EU level.

Cost considerations and the time needed for testing are of great relevance, and the knowledge and data gathered from pilot tests across Europe can provide a significant contribution to validate CCAM functioning and safety.

> Although vehicles with higher level of automation are already starting being deployed on EU roads, their integration into CCAM solutions is not yet sufficiently mature, and current investment levels in CCAM R&I are inadequate to maintain and extend EU industrial leadership. (PD2)

The technological capabilities to cope with the increased complexity of advanced CCAM solutions in operation are not yet sufficiently mature for market take-up. As an example, although shared shuttles are already being deployed in some urban areas, the intrinsic complexity of this environment, the multiplicity of road users and the unpredictability of their behavior still remain challenging in real mixed traffic conditions necessitating more research in the field in the upcoming years.

55 The Operational Design Domains (ODD), introduced by SAE, defines the boundaries of the system functionality at a certain level of automation, e.g. a particular road environment. Each driving mode, i.e. system feature or use case, of an automated driving system is reflecting a particular ODD. With the concept of automation levels and ODD, relevant cases can be distinguished as follows: Level 3 automation means to take the driver out of the perception and response task while keeping him or her as a fallback solution for the dynamic driving task. Level 4 in contrast means there is no driver needed due to the system fallback, but the ODD is limited, while for level 5 the ODD would be unlimited. For all levels up to including Level 4, the ODD is - by definition - limited.

Applications with a viable business case are expected to be deployed in operational domains like motorways with physical separation of oncoming traffic with limited access via merging on- and off-ramps and no low-speed vehicles, bicycles or pedestrians. However, to fully exploit the potential of CCAM solutions more complex traffic situations must also be included and this will require certainty in the investments needed for advancing the necessary vehicle technologies e.g. with respect to perception and control as well as on infrastructure side like cyber-secure connectivity.

In addition, the system approach, should also be deployed so that the integration of the CCAM services into the transport system remain safe, effective and efficient.

Current R&I efforts are fragmented and lack a coherent, longer-term vision and strategy for targeting systemic solutions. (PD3)

Public R&I funding and private investments in CCAM technologies are fragmented and insufficient to maintain and extend EU industrial leadership. To overcome this, it is essential that Research and Innovation efforts are taken beyond the current state with its low level of cohesion. The R&I efforts must be aligned and jointly support the full value chain, while matching a longer term vision in which societal benefits of CCAM enabled mobility represent a core value. Only when this is achieved, R&I investments, as well as other investments in relation to the deployment of CCAM technologies, can enable the European CCAM value chain to maintain and extend their international leadership. Europe's in-depth knowledge base regarding these technologies and their validation, coupled with the understanding of user needs and acceptance and the ability to assess and address CCAM impacts can simultaneously promote international competitiveness.

Demonstration and scale-up is limited, since a well organised, extensive and complex cross-sectorial value chain is still required to build complete CCAM solutions. (PD4)

To build complete CCAM solutions and fully exploit their societal benefits, a well organised extensive cross-sectorial "value network" is required, which today is only partially in place. Effective, profitable and transparent cooperation among local and regional authorities and the private sector involving a multitude of highly diverse stakeholders is mandatory. Including desired impacts as input into the process will contribute to provide end-users with inclusive, equitable and accessible services for all, and to develop interoperable systems and operating conditions. To do so, governance and management readiness is needed. Furthermore, the workforce and educational chain has to be prepared.

There are high costs, risks, barriers and long lead times before R&I investments in CCAM can lead to innovative new products and/or services being widely deployed. Automated mobility, particularly in road transport, is characterised by complex interactions within the overall mobility system. The interdependency of different parts of this system requires that a specific innovation (e.g. new vehicle automation or communication system) needs to be accompanied by timely innovation and roll-out in other segments, such as infrastructure, logistics or business models, for it to have a beneficial impact on the overall system. It also requires cross-sectors synergies with enablers (e.g. electronic components and systems, processing technologies, data driven engineering, Internet-of-Things, Artificial Intelligence) having different time scales for innovations and innovative business models (e.g. "mobility as a service", Logistics as a Service/Physical Internet) to really pay off. Moreover, the advent of automated vehicles opens important new challenges in relation to reliability, security and privacy topics. The Problem Drivers discussed above are summarised in Figure 4: Four Problem Drivers of the CCAM Partnership of the CCAM Partnership.

PD1:

Insufficient demand as society does not yet understand the potential benefits of CCAM enabled mobility. The long-term implications, benefits and impacts of integrating CCAM solutions into the mobility system are not sufficiently examined.

PD2:

Although vehicles with higher level of automation are already starting being deployed on EU roads, their integration into **CCAM solutions is not yet sufficiently mature**, and current investment levels in CCAM R&I are inadequate to maintain and extend EU industrial leadership.

PD3:

Current R&I efforts are fragmented and **lack a coherent, longer-term vision and strategy** for targeting systemic solutions.

PD4:

Demonstration and scale-up is limited, since a well organised, extensive and complex cross-sectorial value chain is still required to build complete CCAM solutions.

Figure 4: Four Problem Drivers of the CCAM Partnership.

7. Objectives of the CCAM Partnership

Advancing CCAM solutions and preparing them for deployment (Deployment Readiness) are key elements of the CCAM partnership vision. The Deployment Readiness is status defined by combining the validated safe system functioning, a good understanding of the expected impact and potential risks, together with users and society's readiness to accept, adopt and demand CCAM solutions. Main actions to achieve Deployment Readiness are Large- scale Demonstrations with pilots, Field Operational Trials (FOT) and in living labs.

A set of agreed objectives address all four Problem Drivers while directing the CCAM Partnership programme towards the expected impacts. The CCAM Partnership differentiates three levels of objectives, which are further detailed in this chapter:

- **General Objectives (GO)** are about what the CCAM Partnership aims at contributing to in the longer term. These are the wider effects on society (incl. the environment), the economy and science enabled by the outcomes of R&I investments (long term). They demonstrate the link with the relevant EU priorities and strategies and targets (see Figure 5).
- **Specific Objectives (SO)** are about what the CCAM Partnership will deliver concretely, where it is to make a difference based on the diffusion and use of the results that will be delivered. (see Figure 5)
- **Operational Objectives (OO)** in the CCAM Partnership are about what is to be delivered during the lifetime of the Partnership, the concrete short-term results of the activities performed/ projects funded. The Operational Objectives are used in the CCAM Partnership to assess the progress over time towards 2030 (see Figure 6 : Operational Objectives (left, blue borderline boxes) contributing to Specific Objectives (right). and Figure 8: The three phases in the CCAM Partnership to monitor the SRIA progress.).

SO1 Validated safety and security, improved robustness and resilience of CCAM technologies and systems.	**GO1** Safe and efficient co-existence between automated and non-automated "conventional" traffic for a long transition period of mixed traffic while overall reducing number of fatalities and injuries in road transport.	**Expected Societal Impact 1:** Improving **safety** and **security** of the transport system drastically
SO2 Secure and trustworthy interaction between road users, CCAM and "conventional" vehicles, infrastructure and services to achieve safer and more efficient transport flows (people and goods) and better use of infrastructure capacity.	**GO2** Increased efficiency of transport flows (people and goods) leading to better use of infrastructure capacity and preservation of public space while reducing transport emissions and congestion	**Expected Societal Impact 2:** Meeting **societal needs** for **mobility** while **reducing environmental** impacts and strengthening our economy
SO3 High public acceptance and adoption of CCAM solutions by 2030 with a clear understanding of its benefits and limits as well as rebound effects.	**GO3** Making Europe a world leader in the development and deployment of connected and automated mobility for people and goods with more focused long-term investments in R&I, development and pre-deployment of CCAM.	**Expected Economic Impact:** Maintain and **extend industrial leadership** for new jobs and economic growth all over Europe
SO4 Better coordination of public and private R&I actions, large-scale testing and implementation plans in Europe.	**GO4** Support the creation, dissemination and capitalisation of knowledge to accelerate the development and improvement of CCAM enabled solutions	**Expected Scientific Impact:** **Strengthen** leadership in all technological and societal aspects of CCAM through targeted **knowledge and capacity building**

Figure 5: Specific Objectives, General Objectives and the Expected Impacts of the CCAM Partnership

The Specific Objectives together with the Operational Objectives (see left side in Figure 6 : Operational Objectives (left, blue borderline boxes) contributing to Specific Objectives (right).) address the Problem Drivers and ensure progress towards Deployment Readiness for different CCAM Solutions and a variety of Use Case. Their implementation all over Europe will contribute to all General Objectives.

OO1
Enable trustworthy interaction between all traffic participants and CCAM by 2028.

OO2
Accepted safety standards for automated mobility on public roads by 2027.

OO3
Common methodologies available to validate the safe system function of CCAM use cases by 2026.

SO1
Validated safety and security, improved robustness and resilience of CCAM technologies and systems.

OO4
Large-scale demonstration of user-oriented and well-integrated CCAM solutions for mobility of people and goods in at least 30 demonstration sites across Europe by 2030.

OO5
Societal impacts are sufficiently addressed and assessed by 2030.

OO6
Increased public awareness of demonstrated benefits for users and society by 2030.

SO2
Secure and trustworthy interaction between road users, CCAM and "conventional" vehicles, infrastructure and services to achieve safer and more efficient transport flows (people and goods) and better use of infrastructure capacity.

OO7
In 2021. establish a long-term coordination framework for R&I and large-scale testing activities.

OO8
Improved synergies for public and private implementation plans to deploy CCAM solutions by 2027.

SO3
High public acceptance and adoption of CCAM solutions by 2030 with a clear understanding of its benefits and limits as well as rebound effects.

OO9
A common evaluation framework fostering exchange and reuse of R&I results by 2024.

OO10
Exploit new and emerging knowledge fields for large scale demonstrations in 2027.

OO11
Expand and disseminate the knowledge base on CCAM solutions during the entire Partnership duration.

SO4
Better coordination of public and private R&I actions, large-scale testing and implementation plans in Europe.

Figure 6 : Operational Objectives (left, blue borderline boxes) contributing to Specific Objectives (right).

The CCAM partnership will contribute to achieving the General Objectives and trigger the expected positive impacts for society (safety, environment, inclusiveness), economy (European competitiveness) and science. The intervention logic describes how the different levels of objectives will at the same time target the Problem Drivers and realise the expected impact (see figure below).

PD2: CCAM solutions are not yet sufficiently mature	Common methodologies available to validate the safe system function of CCAM use cases by 2026.	**SO1** Validated safety and security, improved robustness and resilience of CCAM technologies and systems.
	Accepted safety standards for automated mobility on public roads by 2027.	
	Enable trustworthy interaction between all traffic participants and CCAM by 2028.	
PD4: Demonstration and scale-up is limited	Large-scale demonstration of user-oriented and well-integrated CCAM solutions for mobility of people and goods in at least 30 demonstration sites across Europe by 2030.	**SO2** Secure and trustworthy interaction between road users, CCAM and "conventional" vehicles, infrastructure and services to achieve safer and more efficient transport flows (people and goods) and better use of infrastructure capacity.
	Societal impacts are sufficiently addressed and assessed by 2030.	
	Increased public awareness of demonstrated benefits for users and society by 2030.	
PD3: Lack a coherent, longer-term vision and strategy	In 2021. establish a long-term coordination framework for R&I and large-scale testing activities.	**SO3** High public acceptance and adoption of CCAM solutions by 2030 with a clear understanding of its benefits and limits as well as rebound effects.
	Improved synergies for public and private implementation plans to deploy CCAM solutions by 2027.	
	A common evaluation framework fostering exchange and reuse of R&I results by 2024.	
PD1: Insufficient demand	Exploit new and emerging knowledge fields for large scale demonstrations in 2027.	**SO4** Better coordination of public and private R&I actions, large-scale testing and implementation plans in Europe.
	Expand and disseminate the knowledge base on CCAM solutions during the entire Partnership duration	

Figure 7: Intervention logic of the CCAM Partnership based on Problem Drivers, Operational Objectives. and Specific Objectives.

8. Monitoring progress for Objectives

The intervention logic foresees achieving the Specific Objectives and Operational Objectives in the Partnership timeframe. The timeline of the Programme is structured in three Phases:

- **Phase 1 (2021-2024): Developing the building blocks;**

  This Phase is dedicated to develop the main building blocks in terms of vehicle and infrastructure technologies, key-enablers, methods to engage with users and citizens, as well as methods to validate safe system functioning. Large-scale Demonstrations will focus on less complex usecases with limited ODDs.

- **Phase 2 (2025-2027): Advancing technical maturity;**

  In the second Phase in the programme the CCAM Partnership will advance the technical maturity of technologies by testing and validating in operational environments and if possible already implement in Large scale Demonstrations Projects, or further advance the TRL to prepare them for implementation in the final Programme Phase.

- **Phase 3 (2028-2030): Large-scale demonstrations;**

  The final Phase in the Programme will combine all developments in an integrated Large-scale Demonstration action within Field Operational Trials in Living Labs all over Europe and identify remaining development needs as well as further potential to serve to the societal goals.

Checkpoints, C1 and C2, are introduced where the status towards phase objectives are assessed and the delta captured in reinforcement activities in the next coming concept round. One aspect to infuse further in C1 is how CCAM can support a more efficient transition for clean mobility solutions.

To safeguard the continuity and carry-over of results between projects and phases, the regulatory meetings of the CCAM Partnership will be used as a Forum for internal, and external, benchmark where projects and countries can share findings. The coordination of these activities will be conducted through cluster 7.

The CCAM Partnership allocates the Operational Objectives on the Programme timeline in their logical sequence (see Figure 8: The three phases in the CCAM Partnership to monitor the SRIA progress.).

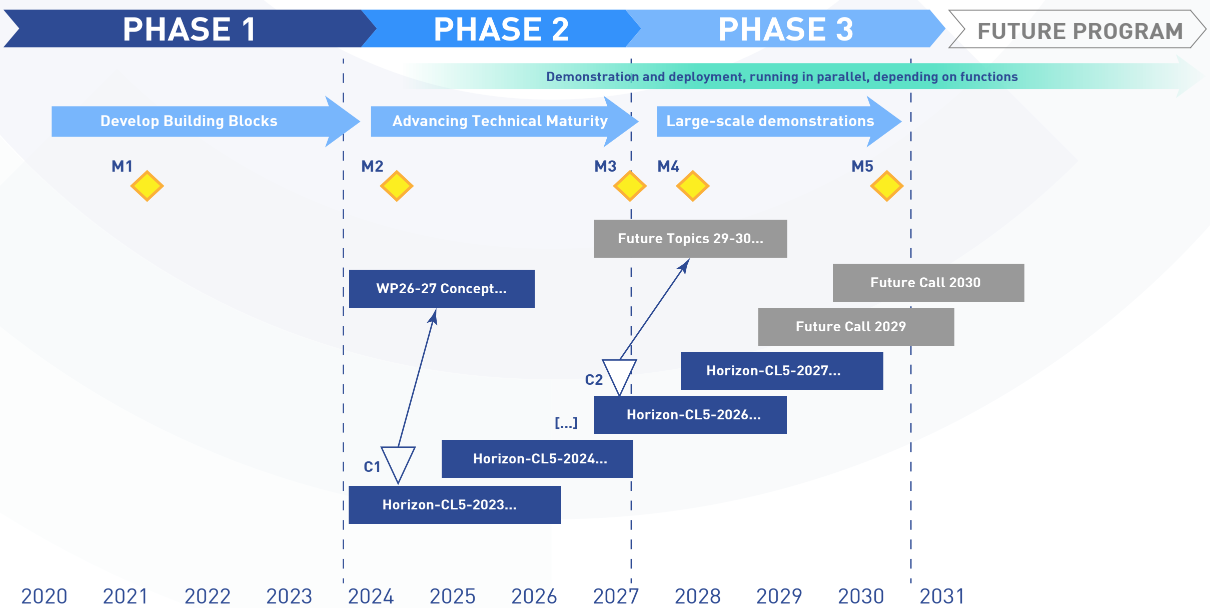


Figure 8: The three phases in the CCAM Partnership to monitor the SRIA progress.

Table: The milestones and checkpoints of Figure 8

M1	Long Term coordination framework for R&I and large-scale testing activities.
	Expand and disseminate the knowledge base on CCAM solutions during the entire Partnership duration
M2	Common evaluation framework fostering exchange and reuse of R&I results
M3	Accepted safety standards for automated mobility on public roads
	Improved synergies for public and private implementation plans to deploy CCAM solutions
	Exploit new and emerging knowledge fields for large scale demonstrations
M4	Enable trustworthy interaction between all traffic participants and CCAM
M5	Large-scale demonstration of user-oriented and well-integrated CCAM solutions for mobility of people and goods in at least 30 demonstration sites across Europe
	Societal impacts are sufficiently addressed and assessed
	Increased public awareness of demonstrated benefits for users and society by 2030
C1	Checkpoint for delta reinforcement in order to achieve target
C2	Checkpoint for delta reinforcement in order to achieve target (envisioning next generation)

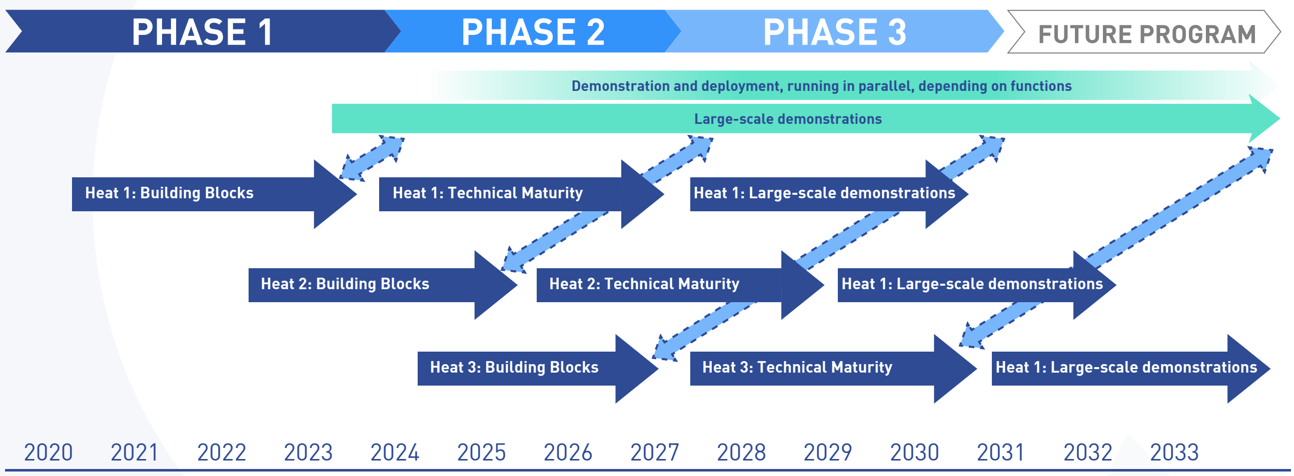


Figure 9: The dimension of iterations allowing new technological building blocks to enter the process, typically with the frequency of a project length. Heats referring to the wave pattern of progress

The identified performance indicators (see tables below) support the partnership progress monitoring and include a limited number of KPIs to assess the contribution of the partnership in achieving the Operational Specific and General Objectives. Reporting on KPIs related to projects will be streamlined according to Horizon Europe rules and definitions.

Throughout the lifetime of the CCAM Partnership, the results of CCAM projects will be monitored and data will be used to support ex-post assessments of the Partnership's impact and its contributions to achieving The General Objectives of the Partnership.

KPIs for monitoring the General Objectives during the partnership lifetime do not add any value, considering the time needed for market introduction and fleet penetration. Assessing the partnership's impacts on general objectives will only be possible after its duration.

The Large-scale Demonstrations (see chapter 7) will be instrumental for assessing the performance and demonstrating value-add, benefits and positive impacts for society. Cross-sector collaboration (especially the integration of energy and automation) is very important from early stages of research on CCAM elements (infrastructure, services and vehicles) onwards to enable seamless deployment for most types of R&I actions. Prospective deployment partners, such as vehicle manufacturers, national or regional road authorities, road operators and mobility service providers, and ICT industries, are key actors already in the early research phases, and work with research and technology organisations (RTOs) and universities to develop CCAM solutions.

Striving for a harmonized output from the Large-scale demonstrations for all use cases (like public transport, passenger car and transport of goods) as well as quality assurance the knowledge sharing between the different projects is essential. A specific track/workshop connected to the RTR conference, including different ODDs (Cities, Long haul Transport, hub-to hub, connected electromobility etc.) will ensure both knowledge sharing and dissemination of best practice for parts of the development not regulated.

Table 4: Monitoring and evaluation framework for General Objectives

General Objectives (GO)	What is a measure of success? Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	Which is the data source and methodology used [project data, study, ….]	Who is responsible for monitoring and providing the data / information? When will it be collected?	Baseline and target
GO1: Safe and efficient co-existence between automated and non-automated "conventional" traffic for a long transition period of mixed traffic while overall reducing the number of fatalities and injuries in road transport.	Number of fatal and severe accidents by vehicles under test in CCAM projects	Reports from large-scale demonstrations	Project coordinators	Baseline: Prospective effectiveness analysis on fatal and severe accidents. Target: Zero fatal and severe accidents caused by vehicles under test in CCAM projects.
GO2: Increased efficiency of transport flows (people and goods) leading to better use of infrastructure capacity and preservation of public space while reducing transport emissions and congestion.	Traffic flow condition[56]: • Travel Time Index, or • Congestion Variability Index, or • Congested Road/kms, or • Peak Hour traffic speed.	CCAM projects and deliverables CORDIS, CINEA data	Partnership Association supported by CSA/ RIA projects and data from CINEA	Baseline: TBD before the test Target: Improvement.
GO3: Making Europe a world leader in the development and deployment of connected and automated mobility for people and goods with more focused long-term investments in R&I, development and pre-deployment of CCAM.	Share of new CCAM vehicles based on European innovation in the fleet of new vehicles sold per year; TEN-T core network corridors' section providing CCAM services Number of sites (e.g. cities) implementing CCAM services after successful demonstration by 2030 (resulting from actions under the CCAM partnership)	CCAM projects and deliverables CORDIS, CINEA data, TEN-T map viewer, CEDR TEN-T performance report, TRIMIS, CCAM Partnership Additional Activities Reporting	Partnership Association supported by CSA projects and data from CINEA	Baseline: Share of CCAM vehicles (SAE level 2, level 3 & level 4) in the fleet 2021 (5%, 0%, 0%), comparable to US and Japan Target: higher than US and Japan in 2023, 2025, 2027 and 2029.Baseline = no corridors with operating sections Target: all 9 core network corridors have sections providing CCAM services by 2030 Baseline: No demonstration Sites yet Target: At least 30 demonstration sites (e.g. urban nodes) implementing CCAM services after successful demonstration by 2030 Baseline: Partners of the CCAM Partnership investment in R&I in 2022. Target: Partners of the CCAM Partnership to increase the investment in R&I by 10% by 2025 and by 25% by 2030.
GO4: Support the creation, dissemination and capitalisation of knowledge to accelerate the development and improvement of CCAM enabled solutions.	Methods, tools and taxonomy used by CCAM developers and deployers in decision making. Number of CCAM projects participating in conferences and events	Qualitative KPI, survey	Project Coordinators, Partnership Association	Baseline: Use of CCAM methods, tools and taxonomy in 2021[57]. Target: Best practise sharing at the Results from Road Transport Research (RTR) conference and at the EUCAD Conference by all HE CCAM projects. Substantial increase in use of CCAM methods, tools and taxonomy

56 Traffic flow condition: the ideal indicator to measure the impact depends on the demonstrated use case, and it could be a combination of the indicators listed.

57 Tools and methods available as of 2021, including from ARCADE (evaluation methodologies collection and data sharing framework) but also other projects like L3Pilot (Code of practice, taxonomy), SHOW, etc.

Table 5: Monitoring and evaluation framework for specific objectives

Specific Objectives (SO)	**What is a measure of success?** Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	**Which is the data source and methodology used** [project data, study, ...]	**Who is responsible for monitoring and providing the data / information? When will it be collected?**	**Baseline and target**
SO1: Validated safety and security, improved robustness and resilience of CCAM technologies and systems.	Methodology for safety validation of CCAM systems agreed by stakeholders along the CCAM value chain, authorities and certification bodies to set safety standards for highly automated vehicles operating on public roads.	Project deliverables, minutes of working group meetings of standardisation bodies and assessment bodies. European and international lists / data-bases of standards.	CCAM Partnership Association, project coordinators	Baseline: HEADSTART methodology based on national efforts (PEGASUS, VVMethods, MOVE/MOSAR and StreetWise), international cooperation (SIPAdus, SAKURA) and EU projects (e.g. L3Pilot, ENSEMBLE, and HiDrive).
SO2: Secure and trustworthy interaction between road users, CCAM and "conventional" vehicles, infrastructure and services to achieve safer and more efficient transport flows (people and goods) and better use of infrastructure capacity.	Number of incidents per 1.000.000 km driven on Large Scale Demo project sites and successfully addressing the causes of these incidents (including malfunctions e.g. false positive detections) from large scale demonstration projects.	Project deliverables and results, assessment reports/ surveys from demonstration projects	Project Coordinators	Baseline: Number of incidents[58] observed in current projects Target: 10% less annually reported incidents per 1.000.000 km driven in projects compared to baseline
SO3: High public acceptance and adoption of CCAM solution by 2030 with a clear understanding of its benefits and limits as well as rebound effects.	Impact of CCAM use on surrogate effects such as fleet composition (of CAV), number of CAV occupants carried, number of CAV VKT (vehicle kilometres travelled), load factors for goods. Survey on acceptance.	Traffic counts in MS (via MS representation in the CCAM Partnership) and projects, surveys (e.g. from demonstration projects)	Project Coordinators	Baseline: Status of MS data from in 2021 Target: 30% improvement of surrogate effects compared to baseline (Baseline available during 2022, choice of surrogate effects starting with states representative group meeting) Baseline: Acceptance survey results from H2020 projects. Target: Increased acceptance in the two next surveys (2025, 2030).
SO4: Better coordination of public and private R&I actions, large-scale testing and implementation plans in Europe.	Active involvement of public and private members of CCAM Partnership, number of cross-border projects, involvement of MS.	CCAM projects and deliverables CORDIS, CINEA, TRIMIS data	Partnership Association supported by CSA projects and data from CINEA	Members of the CCAM Association actively involved in Large Scale Demos. Baseline: 18 States (Member States and Associated Countries) in the first meeting of the CCAM States Representatives Group. 75% of EU member states actively involved in the CCAM States Representatives Group

58 Definition of incidents from the regulation for open road testing.

Table 6: Monitoring and evaluation framework for Operational Objectives

Operational Objectives (OO)	What is a measure of success? Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	Which is the data source and methodology used [project data, study, ….]	Who is responsible for monitoring and providing the data / information? When will it be collected?	Baseline and target
OO1 Enable trustworthy interaction between all traffic participants and CCAM by 2028.	Number of successfully demonstrated new functionalities for trustworthy interaction between road users, vehicles, infrastructure and services delivered by CCAM projects	CORDIS, CINEA, CCAM partnership database, periodical survey,	Partnership association, CSA	Baseline: results of H2020 projects (TrustVehicle, ADAS&ME, Mediator, AutoMate, SUaaVE, interact, BRAVE) to build upon, considering latest advances in science and technology, e.g. in human behavioural models, use of virtual and augmented reality etc. Target: Three or more vehicle-internal and/ or external new HMI functionalities successfully demonstrated in various traffic scenarios and enabling safe and efficient interplay of CAVs with other road users incl. pedestrians and two-wheeler riders Recommendations for user-centric extension of the European Statement of Principles on the design of human - machine interface ESoP towards automated vehicles are available by 2028.
OO2 Accepted safety standards for automated mobility on public roads by 2027.	Number of large-scale demonstrations applying safety standards prepared by CCAM projects. Availability of safety standards recommendations.	CORDIS, CINEA, CCAM partnership database, periodical survey,	Partnership association, CSA	Baseline 2021: No directly applicable safety standards available Targets: 2026, safety standards recommendations available Target: Three or more large-scale demonstrations until 2028 apply safety standards prepared by CCAM projects
OO3 Common methodologies available to validate the safe system function of CCAM use cases by 2026.	Application of methodologies and tools for the safety validation of CCAM, as developed in the CCAM Partnership	CORDIS, CINEA, CCAM partnership database, periodical survey,	Partnership association, CSA	Baseline: H2020 results on validation methodologies: HEADSTART methodology based on national efforts (PEGASUS, VVMethods, MOVE/ MOSAR and StreetWise), international cooperation (SIPAdus, SAKURA) and EU projects (e.g. L3Pilot, ENSEMBLE and HiDrive). Target: All relevant CCAM projects beyond 2026 apply common methodologies and tools for the safety validation of CCAM systems accepted by the relevant stakeholders by 2026
OO4 Large-scale demonstration of user-oriented and well-integrated CCAM solutions for mobility of people and goods in at least 30 demonstration sites across Europe by 2030.	Number of demonstration sites with explicit results on user orientation and mobility integration as well as explicit results on new freight and logistics concepts.	CORDIS, CINEA, CCAM partnership database, periodical survey,	Partnership association, CSA	Baseline: 0 CCAM projects in 2021 Target: 30 or more demonstration sites for people mobility, freight and logistic by 2030

Operational Objectives (OO)	What is a measure of success? Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	Which is the data source and methodology used [project data, study, ….]	Who is responsible for monitoring and providing the data / information? When will it be collected?	Baseline and target
OO5 Societal impacts are sufficiently addressed and assessed by 2030.	Number of projects targeting assessment of societal impacts. Ex-post impact assessment at large-scale demonstrations.	CORDIS, CINEA, CCAM partner- ship database, periodical survey,	Partnership association, CSA	Baseline: Number of projects addressing societal impacts in the Knowledge Base in 2021: 7 out of 16 characterised as addressing "socio-economic impact assessment/ sustainability" by ARCADE. Extended baseline in 2024: Number of WP21-22 CCAM projects which are mapping aspects of methodology that can be related to societal impacts assessment. Target: All demonstration projects of CCAM Partnership show completed mapping of these aspects. All impact aspects defined are assessed by 2030 (Ex-post impact assessment of large-scale demonstrations)
OO6 Increased public awareness of demonstrated benefits for users and society by 2030.	Evolvement of public awareness and perceived benefits with the help of assessment reports of large-scale demos	FIA, EUROBAROMETER, CORDIS, CINEA, CCAM partnership database, periodical survey,	Partnership association, CSA	Baseline: (Surrogate measures from Eurobarometer 496 2019 and L3 Pilot survey 2021.) **1.** Survey results from Eurobarometer 496 on "fully automated and connected vehicles": Awareness = has seen, heard, read something about AV last year: 60% Willingness to use "fully automated and connected vehicles": 47% **2.** For level 3 cars (L3Pilot questionnaire results; 2021): Willingness to use automated vehicle: 60% Willingness to buy: 28% Target: By 2030: Public awareness: 100%; Willingness to use: 75%; Willingness to buy: (56% (=doubling)).
OO7 In 2021, establish a long term coordination framework for R&I and large scale testing activities.	Number of projects making datasets available or use data from other projects (e.g. linked through the Knowledge Base) Regularly updated SRIA of the CCAM Partnership.	CORDIS, CINEA, CCAM Knowledge Base, periodical survey,	Partnership association, CSA	Baseline: Best practices from Knowledge Base. Target: All CCAM projects make test data and other datasets (e.g. scenarios, edge cases, etc.) available by 2027. Baseline: SRIA and CCAM Partnership established in 2021. Target: Regular updates of the CCAM SRIA.
OO8 Improved synergies for public and private implementation plans to deploy CCAM solutions by 2027.	Active involvement of regional and local authorities and their representatives in the CCAM projects.	CORDIS, Partnership report (e.g. Annual basis), Cluster 7 RIA,	Partnership association, CSA	Baseline: 15 in the first CCAM projects from WP2021-22. Target: 50 in all CCAM projects.

Operational Objectives (OO)	What is a measure of success? Please use quantitative (Key Performance) and qualitative indicators, and link them to a point in time	Which is the data source and methodology used [project data, study, ….]	Who is responsible for monitoring and providing the data / information? When will it be collected?	Baseline and target
OO9 A common evaluation framework fostering exchange and reuse of R&I results by 2024.	Common evaluation methodologies (CEM) implemented and building up a common evidence base using CEM for CCAM demonstration activities. Number of projects making reference to common evaluation methodology in their methodology definition, also beyond European projects after finalisation of the CEM.	CORDIS, CINEA, CCAM Knowledge Base, periodical survey, Project deliverables and results, assessment reports/surveys from CSA projects	Project Coordinators, Partnership association, National Member States representatives CSA	Baseline: good practices from the Knowledge Base on evaluation methodologies Extended Baseline: CEM ready for implementation by 2024 Target: 10 or more projects making reference to common evaluation methodology in their methodology definition, also beyond European projects by 2027
OO10 Exploit new and emerging knowledge fields for large scale demonstrations in 2027.	Number of projects developing and implementing new and emerging knowledge fields, such as cyber security, data sharing and AI, into CCAM solutions.	Cluster 5 RIA, CCAM Knowledge Base, TRIMIS	Project Coordinators, Partnership association	Baseline: Mapping of knowledge fields of the Cosmos project in 1. Quarter 2022 Target: 15 Horizon Europe projects addressing new and emerging knowledge fields like AI and cyber security in CCAM applications by 2027 (no baseline)
OO11 Expand and disseminate the knowledge base on CCAM solutions during the entire Partnership duration.	Number and regularity of updates of the CCAM Knowledge Base with projects and high qualitative content providing results and lessons learned	CORDIS, Partnership report (e.g. annual basis), Cluster 7 RIA,	CCAM Partnership Association	Baseline: Knowledge base in 2020 with 300 projects (covering projects as of 1996) Target: 400 or more projects in total by 2030 Baseline: 50% (all Eastern European countries, Portugal, Luxemburg, Ireland) of all the 26 European countries with projects are significantly under-represented in the Knowledge Base in 2021 with involvements in less than 8 projects. Eastern countries in particular are involved in average in 3 projects. With few exceptions (US and Japan), no project from outside EU is included in 2021. In 2021, the KB includes initiatives from EU, Norway, Switzerland and UK and very few initiatives involve US, Brazil, Canada, China, Japan, New Zealand, South Korea) Target: Increase the number of CCAM related projects from all Eastern European countries, Portugal, Luxemburg, Ireland and from non-European countries in the Knowledge Base by 2030.

9. CCAM Clusters

The CCAM Partnership will align perspectives from road users/consumers, public policymakers, road operators, Cities and transport authorities and industry to make CCAM solutions and services ready for deployment and bring gains in safety, sustainability, efficiency and inclusiveness to the overall transport system.

A focal point of the CCAM Partnership approach is the design and development of a user-centred and all-inclusive mobility solution enabled through digitalisation and automation. The state-of-the- art technologies in 2020 are either limited in

- **speed (e.g. below 40 kph);**
- **operational domain (e.g. confined areas); or**
- **ability to handle complex traffic (e.g. motorway only);**
- **limiting ambiental factors.**

The ambition of the CCAM Partnership is to advance these technologies, systems and solutions, pushing these boundaries (i.e. expanding the ODD) that allow innovative and new Use Cases. Research and technological progress for vehicles, infrastructure and the entire transport system will push the limits:

- **higher speeds: 80 – 120 kph;**
- **extended operational domains: hub-to-hub transport; specific road class;**
- **complex traffic: urban and peri-urban driving;**
- **all weather conditions.**

However, a key challenge remains to ensure the safe system functioning; to design and prove that a complex CCAM solution; without the human driver as the major fallback role for the dynamic driving task, is functionally and operationally safe. A long transition phase or even indefinite coexistence is expected, with both conventional and CCAM vehicles with specific traffic management needs, ensuring good co- existence and vulnerable road users' protection. More efforts are required to enable and prove safe system functioning in larger operational design domains (ODD) due to the scaling complexity (i.e. demonstrating maturity). An unlimited operational domain seems unrealistic with the 2021 perspective on applicable state-of-the-art technologies (SAE Level 5 is a theoretical description of ultimate automation; it merely gives a direction and not a realistic outcome).

Use Cases specify the requirements of a process or a business model and correspond to a set of actions that in this case the CCAM solutions may perform in interaction with its users (and/or other actors/ systems). This sequence of actions produces an observable result that contributes to the objectives of the actor(s) (e.g. move from A to B with reduced environmental impact). A Use Case is named according to the specific user-goal for its primary actor. Use Cases for CCAM solutions are mainly distinguished by the complexity of the traffic situations and/or vehicle speeds (linked to the ODD).

Operational Design Domains (ODDs) comprise various (also adverse) environmental and road conditions and critical combinations of them, the whole bandwidth of traffic scenarios as well as the infinite variety of technological solutions and their performance on the road including external data sources from physical and digital infrastructure support in various levels. Differences in terms of type and maturity of CCAM systems and services in the different geographical areas are expected.

The CCAM Partnership will achieve Deployment Readiness for specific Use Cases in the short-/ medium-term (3-5 years) or long-term (7-10 years) by expanding the ODD and demonstrating maturity.

The selection of Use Cases (and their ODDs) for demonstrations (in short, medium and long-term) are not predefined, allowing agile and open innovation processes, considering new mobility services and solutions. Less complex Use Cases as driving on highways or in confined areas as well as low speed applications in mixed traffic will be earlier ready for deployment. Driving at higher speeds in mixed city traffic and in peri-urban environment due to scaling complexity (see above) will come later. The overall goal and long-term ambition for CCAM is providing services and solutions for passengers and freight in as many relevant application areas as possible.

These challenges require three steps:

(1) understanding the needs of users, society, and other stakeholders,

(2) advancing technologies, and

(3) demonstrating the maturity of mobility and transport services at a large scale.

Large-scale Demonstrations in Pilots, Field Operational Trials (FOTs) and in Living Labs (see definitions in Chapter 7.1) provide enough evidence for showing Deployment Readiness and partnership's success (step 3). These demonstration activities close the loop in the co-creation process by proving the match between people needs and societal requirements, providing relevant data for impact assessments, and accelerating the technical development process. They support the uptake of innovative mobility solutions and/or logistics services with connected and highly automated vehicles for passenger and freight transport.

A fully integrated Large-scale Demonstration within Living Labs across Europe with many mobility Use Cases (shared and individual) covering needs for people and goods transportation will achieve the following objectives:

- Demonstrate inclusive, human-oriented and well-integrated mobility concepts enabled by CCAM with a reduced carbon footprint and reliable predicted travel times;
- Demonstrate new freight and logistics concepts and services enabled by CCAM with a reduced CO_2 emission per tonne-km, further reducing congestions;

and, provide ample evidence that societal impacts (e.g. safety, traffic efficiency, quality of service, environment) and wider economic impacts are sufficiently assessed, addressed, and accepted.

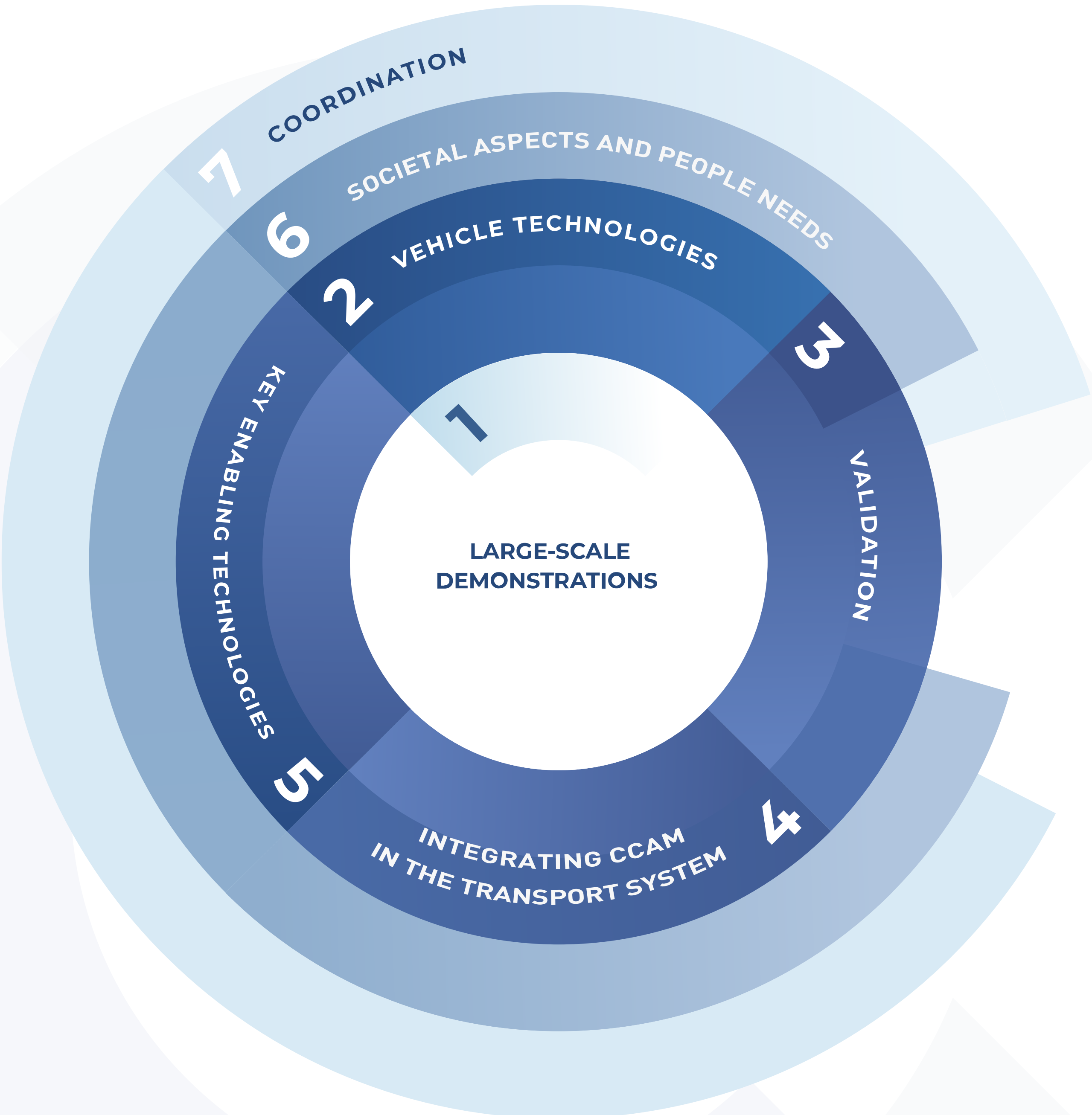


Figure 10: The seven CCAM clusters

The CCAM Cluster structure (see Figure 10) shows the links between specific R&I actions and the progress towards the Operational Objectives (Chapter 5, see Figure 11: Clusters contributing to achieving the Operational Objectives (OO) of CCAM.) of the Partnership. The Clusters are interlinked and each Cluster provides input to other Clusters. Together they form a comprehensive framework for achieving the Partnerships' Specific and General Objectives and delivering the expected impacts.

The starting point is the understanding of the people needs and societal aspects of mobility (see description Cluster 6), advancing technologies (see Cluster 2, Cluster 4 and Cluster 5) and demonstrating the maturity at a large scale (see Cluster 1 and Cluster 3).

Key enabling technologies (see Cluster 5) are needed to enhance solutions. These will be implemented together with future vehicle technologies for sensing, sensor fusion and enhanced safety systems (see Cluster 2). The overall transport system integration complements safe human- machine interaction to understand the requirements and needs for traffic and fleet management and provide physical and digital infrastructure support (see Cluster 4).

Before demonstrating at a large scale (see Cluster 1), safe and resilient system functioning needs to be validated (see Cluster 3). All activities are linked through coordination (see Cluster 7) of all relevant stakeholders, ensuring alignment, interoperability and accelerating innovation uptake.

Cluster 1: Large-scale Demonstration. The objective of Cluster 1 is to continuously implement results of all other Clusters into Large - scale Demonstrations in Pilots, FOTs and Living Labs supporting deployment readiness and a final impact assessment.

Cluster 2: Vehicle technologies. This Cluster aims to deliver the most efficient and effective future solutions which have been proven to be safe and reliable. For Europe's future mobility and transport system, significant technical research and innovation challenges must be overcome since tomorrow's highly automated vehicles will rely on advanced solutions to "sense-think-act', enabling safe interaction with other road users and providing protection in the case of emergency, while also ensuring the well-being of the vehicle occupants.

Cluster 3: Validation. This Cluster will provide the procedures, methodologies and tools which are needed for validating, verifying and rating CCAM systems, in terms of both technology itself and human factors handling the technology. This will include suitable metrics and references for system behaviour and performance.

Cluster 4: Integrating CCAM in the transport system. The research and innovation projects in this Cluster will advance the physical and digital infrastructure support for CCAM vehicles and improve connectivity and cooperation between actors, which will support the integration of CCAM vehicles in the overall transport system so that fleet and traffic management systems can be enhanced.

Cluster 5: Key enabling technologies like Artificial Intelligence, Big Data, cybersecurity and Edge computing will support the whole mobility system consisting of vehicle technologies, integrating the vehicles in the transport system, as well as the validation of all aspects of the entire system. Cluster 5 is embedding the "Key enabling technologies" with technical details, contributions, requirements and risks for Cluster 2, 3 and 4.

Cluster 6: Societal aspects and people needs. This Cluster delivers the framework for understanding and taking into account user and citizen needs, and societal aspects of mobility to all other Clusters. Methods and measures for societal impact assessment will be developed and applied when executing the final societal impact assessment from Cluster 1 results.

Cluster 7: Coordination. This Cluster is coordinating all CCAM stakeholders and activities, facilitates knowledge exchange und enables lessons learned.

Each Cluster contributes to delivering the Operational Objectives of the CCAM Partnership as described in the following subchapters in more detail. This description includes a state of the art; an overview of required R&I actions; a timeline description; and the expected outcomes by the end of the CCAM SRIA time frame (i.e. 2030).

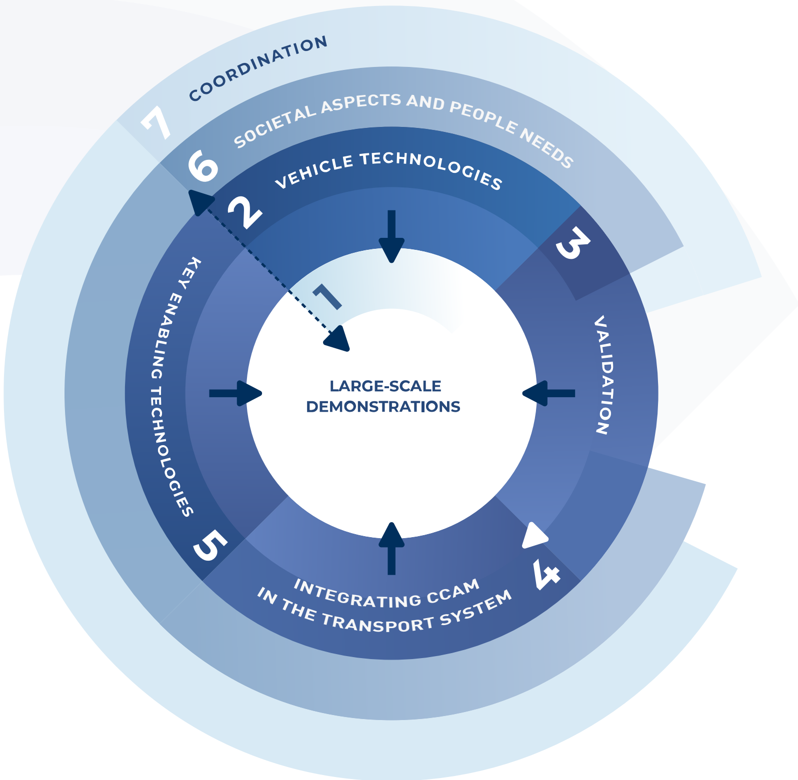
		Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7
007	Establish a long-term coordination framework for R&I and large-scale testing activities.	✓	✓	✓	✓	✓	✓	✓
009	A common evaluation framework fostering exchange and reuse of R&I results by 2024.							✓
003	Common methodologies available to validate the safe svstem function of CCAM use cases by 2026.		✓	✓	✓			
008	Improved synergies between public and private investment plans to advance vehicle and infrastructure technologies.	✓			✓			✓
002	Accepted safety standards for automated mobility on public roads by 2027.			✓				✓
0010	Exploit new and emerging knowledge fields for large scale demonstrations in 2027.	✓				✓		✓
001	Enable trustworthy interaction between all traffic participants and CCAM.	✓	✓	✓	✓	✓		
004	Large-scale demonstration of user-oriented and well-integrated CCAM solutions for moblity or people and goods in at least 30 demonstratior sites across Europe by 2030.	✓					✓	✓
006	Increased public awareness demonstrated benefits for users and society by 2030.	✓					✓	✓
005	Societal impacts are sufficiently addressed and assessed by 2030.	✓					✓	
0011	Expand and disseminate the knowledge base on CCAM solutions during the entire Partnership duration.	✓	✓	✓	✓	✓	✓	✓

Figure 11: Clusters contributing to achieving the Operational Objectives (OO) of CCAM.

9.1. Cluster 1: Large-scale Demonstration

Introduction

CCAM solutions shall provide a more user-centred, all-inclusive mobility, while increasing safety, reducing congestion, harmful emissions and contributing to decarbonization.



Novel mobility services can enable seamless integration with existing services (e.g. public transport, logistics), and higher levels of automation are expected to support transport productivity and efficiency (e.g. transportation of goods at lower speeds to save energy, operational efficiency at logistics hubs and in hub-to-hub corridors or last mile operations). Yet, all these benefits need to be proven as well as demonstrating the technical maturity of the CCAM solutions. Previous and currently (in 2021) ongoing demonstration projects for individual and shared mobility for CCAM systems and services covering needs for transporting people and goods show that further testing of highly automated systems with high-scaling potential is necessary.

The objective of Cluster 1 is to

ensure that the results of all other Clusters are capitalized and implemented into Large -scale Demonstrations in Pilots, FOTs and Living Labs to support deployment readiness and a final impact assessment. Cluster 1 will:

- Build on CCAM technologies, methods, systems and services developed in Cluster 2, 3, 4 and 5.
- Leverage on results from all Clusters by implementing and well integrating concepts in complete end-to-end mobility services for real life conditions, while involving key stakeholders such as, end users in their daily life, vehicle industry, public authorities, public and private operators, service providers, telecom, logistics etc.
- Align with Cluster 6 in order to consider societal needs and expectations, as well as use cases that are useful and needed by the people, assess the impacts of inclusive user-oriented integrated personal and shared mobility in addition to new concepts for freights and logistics enabled by CCAM with a reduced carbon footprint and reliable predicted travel times.
- Coordinate with Cluster 7, as overarching cluster, to link the R&I and testing activities across Europe in achieving a successful cross-sector collaboration between all stakeholders. Cluster 1 projects will be involved in the development of the coordination tools by Cluster 7 and should use them to ensure comparability and complementarity of results and exchange of data, lessons learned and best practices. Tools include the EU wide Knowledge Base and the EU framework for Testing on public roads (Common Evaluation Methodology, Tests Data Sharing Framework, ...).

- Provide feedback and lessons learned to all Clusters, reporting on limitations of used technologies and/or proven maturity as well as minimum requirements to be met across Europe regarding regulations.

Advancing the State of the Art

Starting from the EU projects under Horizon 2020, AVENUE, SHOW, L3PILOT, AWARD, Hi-DRIVE and ENSEMBLE have covered the three development paths present in the ERTRAC roadmap (shared and individual mobility as well as trucks and goods). The Horizon Europe projects, MODI and ULTIMO will extend these with a strong service and economic viability orientation.

AVENUE [59] trials start with low-speed public transport applications on low complexity surroundings in different locations. The limited Use Cases with the ambition to go for on-demand mobility services address also elderly and handicapped persons.

L3PILOT [60] has set up an open testing methodology including data exchange formats and a code of practice, for piloting SAE Level 3 vehicles that guides through the complete development of automated technology with a focus on testing. The results from testing automated valet parking and highway automation features will support the further research work on SAE L4 Parking and SAE L3 Highway driving.

ENSEMBLE [61] showed various approaches to truck platooning support functions as well as strategic insights into truck automation ongoing. Also, the work on impact assessment will be very important. In each of these projects you can see that there are still many R&D challenges: the technology is moving forward but there are still many substantial efforts to be done.

SHOW [62] aims at supporting the migration path towards affective and persuasive sustainable urban transport through technical solutions, business models and priority scenarios for impact assessment, by deploying shared, connected, electrified fleets of L4 automated vehicles (buses, shuttles, pods, robo-taxi, automated cars and cargo vehicles) and for all operators in coordinated Public Transport (PT), Demand Responsive Transport (DRT), Mobility as a Service (MaaS) and Logistics as a Service (LaaS) operational chains in real-life urban demonstrations taking place in more than 20 cities across Europe.

AWARD [63] develops and deploys a safe autonomous transportation system applicable to a wide range of real-life occurrences and scenarios. Specifically, the project provides an autonomous driving system capable of confronting adverse environmental conditions such as fog, heavy snow and rain.

Hi-DRIVE [64] pushes automated driving further towards high automation. The goal is to make driving automation robust and reliable by taking intelligent vehicle technologies to conditions and scenarios neither extensively tested nor demonstrated earlier in European and overseas traffic. Hi-Drive addresses a number of key challenges which are currently hindering the progress of developments in vehicle automation.

MODI [65] identifies and addresses barriers in confined areas and on public roads to enable an early integration of CCAM in current logistic vehicle operations. Beyond the demonstration of solutions on the corridor from Rotterdam to Oslo, the project investigates business models for the logistic sector.

59 https://h2020-avenue.eu/

60 https://www.l3pilot.eu/

61 https://platooningensemble.eu/

62 https://show-project.eu/

63 https://award-h2020.eu/

64 https://www.hi-drive.eu/

65 https://cordis.europa.eu/project/id/101076810

ULTIMO[66] aims to deploy in three sites in Europe 15 or more multi-vendor SAE L4 AVs per site. A user centric holistic approach, applied throughout the project, will ensure that all elements in a cross-sector business environment are incorporated to deliver large-scale on-demand, door-to-door, well-accepted, shared, seamless-integrated and economically viable CCAM services.

The building blocks on user aspects, regulatory considerations, impact assessment, safety and cybersecurity requirements – to name the most important ones – will be implemented by Cluster 1 to plan and direct the Large-scale Demonstrations in the future towards the CCAM Partnership objectives. All other Clusters in CCAM will provide input and contributions into this process.

R&I Actions and Expected Outcomes

The R&I Actions in Cluster 1 bundle all Large-scale Demonstration activities in the CCAM Partnership, moving towards Deployment Readiness. The actions will focus on urban, inter- urban, sub-urban/ peri-urban regions, hub-to-hub and long-distance transport corridors using highways and rural roads.

Demonstration of automated combined people and goods operations will make a big step forward to test and evaluate new operational and business models in realistic scenarios. The integration of CCAM solutions in Large-scale Demonstrations all over Europe will foster harmonisation and interoperability while facilitating co-creation with society and users, showing benefits and fostering adoption of new mobility services.

A structured approach will be applied to fulfill this ambitious objective of the central Cluster 1.

From technology point of view, the demonstrated Use Cases in Cluster 1 will either

- increase speed limitations, and/or
- increase operational design domains (in relation to geography and roadway types but also to speed capability and weather), and/ or
- increase complexity of maneuvers and handling of more complex traffic situations

by integrating results from Cluster 2, Cluster 4 and Cluster 5.

From a societal point of view, the Use Cases will be embedded in real life applications ensuring they are useful to reach the mobility goals addressing the needs and expectations of CCAM users (Cluster 6).

These Use Case(s) will be demonstrated using appropriate methods for the Large-scale Demonstrations depending on the maturity of the Use Cases, the complexity of its ODD as well as the main research ambition. Highly challenging Use Cases in mixed traffic in high-density inner-city traffic and high speeds on rural roads are expected to follow less complex use-cases on highways and in confined areas.

The demonstration actions may use the following methods:

- **Pilots (TRL 6-7)** are used for integrating and testing several technological enablers and demonstrate their safe use in combination. The pilots are used to prove with prototype vehicles and applications the safe functioning of the solution with test drivers in operational environments.
- **Field Operational Trials (FOTs, TRL 8)** are used to enhance user acceptance and adoption by demonstrating functionality to end-users. Large-scale Demonstrations in FOTs are closer to deployment delivering detailed test data that is comparable to real life data with impacts on users and the potential of technologies for adoption and understanding of risks and benefits.

66 https://ultimo-he.eu/

- **Living Labs (TRL 8)** demonstrate solutions with communities and expose the technologies towards society. In the CCAM Partnership, the Living Labs provide the entire infrastructure (including connectivity), mixed dynamic traffic environments and users and communities with vehicles from small-series production with fully integrated functionality and user interface. These Large-scale Demonstrations will facilitate R&I actions in co-creation with society, emphasizing quality-of-service and usability and impacts on everyday life of citizens.

The integration of results from Cluster 2, Cluster 4 and Cluster 5 will be demonstrated to evaluate safe and robust system functioning. Use Cases will demonstrate higher levels of automation with connectivity to support transport productivity and efficiency, transportation of goods at lower speeds to save energy, operational efficiency at logistics hubs and in such as: transportation of goods at lower speeds to save energy, operational efficiency at logistics hubs, hub-to-hub, corridors and automated last mile operations.

More mature technologies will be demonstrated together with users and stakeholders, to understand how to gain trust and speed-up adoption. Living Labs will be used to demonstrate functionalities and impacts with communities and understand the impacts on society.

In the final phase the CCAM Partnership programme will demonstrate the full potential of new solutions, business models as well as facilitating (ex-post) assessment of societal and environmental impacts (Cluster 6). This requires a framework for public procurement of new road transport services, facilitating the uptake of new businesses and operational models.

For all R&I Actions in Cluster 1, public and private stakeholder collaboration will be required to achieve the common objectives. European wide demonstrations, including non-homologated vehicles and applying a common testing regulation framework (see Cluster 7) will deliver evidence for Deployment Readiness with quantitative data for ex-post impact assessments (Cluster 6).

Expected outcomes

- Demonstration of inclusive, user-oriented and well-integrated shared CCAM systems and services for people and goods in real traffic conditions (see CCAM-1).
- Evidence on expected impacts for safety, environment, health, economy, land-use considering of the evolution of mobility services for people and goods through testing of relevant Use Cases and ODDs that both match society needs and expectations, making the traffic and transport system more efficient.
- New market opportunities and new business models identifying and reflecting on end-users needs for integrated, co-created and convincing business models, leveraging the return-on- investment potential of innovative cross-sector CCAM.
- Inclusion of all relevant stakeholders[67] needed to demonstrate CCAM for individual and shared mobility of persons and goods.
- Strengthen the close link with users and society facilitating co-creation, adoption and up-take of CCAM addressing risks, reservations and anxieties of citizens.
- Interoperability including cross-border functionality all over Europe.
- Harmonisation of definitions in the various approval frameworks of testing license procedures across countries and regions on public roads.

---

67 Privateandcommercialend-users,allparticipatingindustries,transport/mobilityoperatorsforpersonsandgoods,aswellaspublicauthorities including ports, terminals, cities and municipalities

- Encouraged development of a standardised procedure for homologation independent of OEM or supplier and promote the framework for public procurement of new public/shared road transport (e.g. pods, shuttles).
- Training and education concepts for professional drivers and private citizens including costs related to retraining current drivers.

Timeline

The different R&I Actions in Cluster 1 depend on the technical maturity of the Use Case and the complexity of its ODD. We define 3 levels that advance through time in maturity and robustness, see Figure 12: Cluster 1 R&I Actions over the Partnership Programme timeline.

Stage 1 - "Selected Use Cases in limited ODD": This level represents the 2021 state of the art technologies used in European Pilot actions from Horizon 2020 and from the projects starting in 2022. Demonstration actions in Stage 1 facilitate Use Cases within "limited ODDs" (for example slow speeds, or in confined areas, or with less complexity). With the end of Horizon 2020 Pilot projects, and their results demonstrating the safe functioning, reliability, and robustness in limited ODDs.

Stage 2 - "Combined Use Cases in extended ODD": Demonstrations of Use Cases with extended ODDs with increased complexity - yet limited domains. These CCAM solutions will test safety, reliability, and robustness in operational environments. After successful testing the Use Cases could be implemented from 2026 onwards and demonstrate the functionality and impacts to end-users while facilitating adoption. Demonstrations will be done with users, society, business and operational demands.

Stage 3 - "Complex combined Use Cases in large integrated ODD": This Stage facilitates several Use Cases in a large integrated ODDs covering different road categories at their speed limits, handling more complex urban traffic situations, adverse weather conditions, road constructions and tunnels, etc. This level will further integrate results from Cluster 2, Cluster 4 and Cluster 5 while building on Use Cases from Stage 1 and Stage 2 as well as new identified Use Cases enabled through the large integrated ODD. Demonstrations will be performed throughout Europe together with key stakeholders, end-users and society, integrating many Use Cases and new mobility services in a complex large integrated ODDs.

Cluster 1 Large-scale Demonstrations

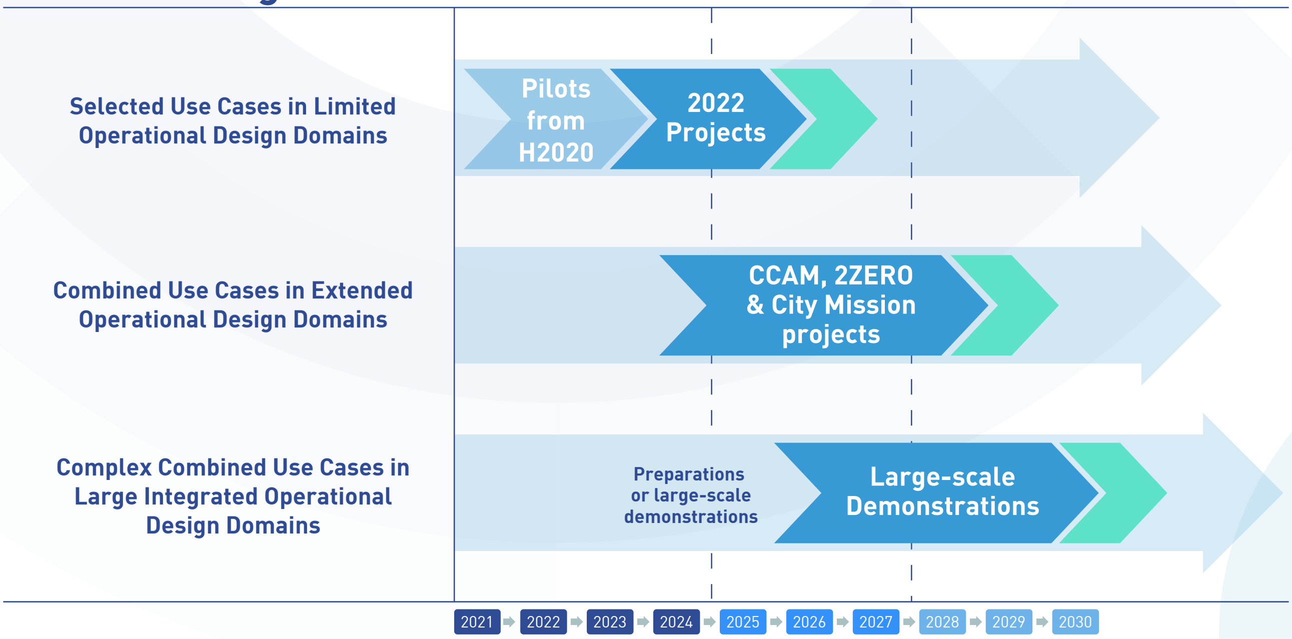
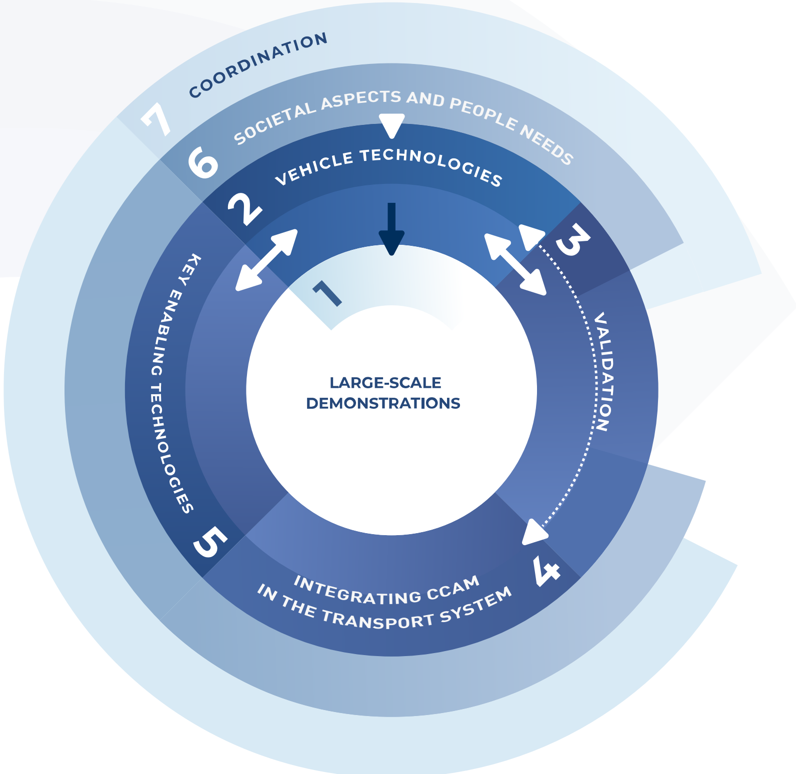


Figure 12: Cluster 1 R&I Actions over the Partnership Programme timeline.

9.2. Cluster 2: Vehicle Technologies

Introduction

Cluster 2 "Vehicle Technologies" focuses on the development of technologies on-board of connected and automated vehicles (CAVs) to perceive the environment and take decisions, enabling safe interaction with other road users and providing protection in the case of emergency while also ensuring the comfort and well-being of the vehicle occupants.



Robust and accurate environment perception is absolutely essential for highly automated vehicles to enable the extraction of reliable information for real-time driving decision-making which must be performed in a safe and unambiguous way, concentrating on the combination of system, human and environment status within the framework of digital traffic rules.

The imminent transformation of the electronic control architecture and the embedded code and data will pave the way towards a decoupling of hardware and software that accelerates innovation and enables harmonized safety functionalities in automated and connected vehicles and their integration in the cloud.

Cluster 2 will

- Deliver vehicle technology ready for demonstration on public roads, including functional safety[68], safety of the intended functionality[69] and cybersecurity (to Cluster 1).
- Provide recommendations for a European Statement of Principles (ESoP) for automated vehicles to enable conformity checks (to Cluster 3).
- Provide improved vehicle technologies (e.g. sensor fusion, on-board decision making) contributing to better performance of vehicle-transport system integration also with respect to shared and regularly-updated high-definition maps of the environment (to Cluster 4).
- Specify vehicle technology needs for advancing e.g perception capabilities through key enabling technologies (to Cluster 5).
- State requirements for the co-design of e/e-architecture and operating systems in view of automated functionalities and cloud connection (to KDT partnership)

68 ISO 26262-1:2018 Road Vehicles – Functional Safety, https://www.iso.org/standard/68383.html

69 ISO/PAS 21448:2019 Road Vehicles – Safety of the intended functionality (SOTIF), https://www.iso.org/standard/70939.html

Indeed, safe and reliable CCAM solutions will not be feasible without robust and accurate environment perception technologies.

Comprehensive environment perception capabilities are required that can reliably identify, track, and discriminate between benign and hazardous objects in the path of the vehicle under the full range of environmental conditions in which the vehicle is intended to operate (e.g. adverse weather and lighting conditions).

A significant technological challenge is presented by the wide variety of traffic participants with completely different characteristics that might enter the viewing area of the sensors, thus enforcing the need for a multitude of different sensing devices with different attributes depending on the specific task. To address this challenge, a variety of technical solutions have been adopted to date, the result being that a multitude of different sensor set-ups exist which vary considerably in terms of the number and type of sensors and their positioning on the vehicles.

Essentially automated driving requires that multiple systems interact with each other within a "Sense-Think-Act" process: The vehicle needs to perceive all surrounding objects and localise itself in the environment ("environment perception") before selecting all relevant objects to be considered for the subsequent motion planning task ("decision-making"). Hence the vehicle systems need to take into account not only the current situation, but also predict the relative movement of the ego- vehicle (the vehicle equipped with the automated functionality that performs the Dynamic Driving Task autonomously) with respect to all relevant objects while anticipating the path trajectory of the other road users.

Another technological challenge is the need for a shared high-definition (HD) map of the environment, a prerequisite for the precise localization of the highly automated vehicle for high level situation awareness; the HD map also requires regular updating as the environment evolves frequently especially in urban and peri-urban contexts (e.g. construction sites and public works).

In general, the electric and electronic components of automated and connected vehicle need to interact in an efficient, reliable and fail-operational way with each other and with the embedded software and artificial intelligence at the edge, which is being increasingly facilitated by more centralized vehicle control architectures which importantly allow also software-over-the-air updates.

Advancing the State of the Art

Several different sensing sources (using technologies including radar, lidar, ultrasonic sensors, cameras, etc.) can be aggregated with "sensor-fusion" to enable the vehicle to perceive its surroundings before function-specific software uses the information as input to think and act appropriately, deciding which actions the vehicle shall take before executing them accordingly. A series of recent and on-going EU projects have addressed environment perception and on-board decision-making, and the development of relevant technologies.

The **RobustSENSE**[70] project focused on introducing reliable, secure and trustable sensors and software by implementing self-diagnosis, adaptation and robustness, developing metrics to measure sensor system reliability on every level of assistance and automation systems.

Research on how to deal with the variety of environmental conditions has been performed in the **DENSE**[71] project, the objective being to develop and validate an all-weather sensor-suite for traffic services, driver assistance and automated driving. The new sensor-suite is based on a smart integration of three different technologies to demonstrate the potential of all-weather environment

70 https://robustsense.eu/

71 https://www.dense247.eu

perception: radio radar, gated short-wave infrared camera with pulsed laser illumination, and short-wave infrared LIDAR.

The **Dreams4Cars** [72] project aimed at setting up an offline simulation mechanism in which robots can produce a simulated world by recombining aspects of real-world experience, collectively interacting to safely develop and improve sense-think-act systems, focusing in particular on the analysis of rare events.

The current **ROADVIEW** [73] project is developing robust and cost-efficient embedded in-vehicle perception and weather-aware decision-making systems for connected and automated vehicles with enhanced performance under harsh weather conditions.

The ongoing **EVENTS** [74] project aims to improve perception and decision-making algorithms focusing on VRUs and CAVs in complex environments and under adverse weather/lighting condition.

In addition to perceiving the surrounding environment, locating the ego-vehicle in this environment is an important step for the execution of automated driving functions, requiring the utilisation of advanced digital mapping technologies.

As the amount of data and information increases with higher levels of automation, so too does the need for more computational power with new software required to handle and process the data, increasingly involving AI and Machine-Learning techniques. Such software-intensive systems must be designed to provide very high safety levels so that the rate of errors in the requirements, specifications, and coding is sufficiently low for the system to be effectively as safe as, or safer than, human driving.

For future, highly automated vehicles in which the human driver cannot be considered as a backup, systems must be "fail operational" such that, in the event that the limit of the Operation Design Domain (ODD) is reached, the vehicle brings itself into a safe state with a minimum risk manoeuvre. Hence the automated driving system must be provided with comprehensive fault detection, identification and accommodation capabilities so that malfunctions can be immediately diagnosed and enable switching to a fall-back mode of operation in order to ensure safety.

Active safety functions need to enable automated vehicles to navigate safely in both expected and unexpected scenarios, with advanced passive safety systems also being required to protect passengers in new, unconventional seating positions.

In practice, highly automated vehicles will bring new challenges in terms of traffic rules and new regulations may be needed. In this context, the EU Project **OSCCAR** [75] is applying a comprehensive, integrated approach for the development of future advanced occupant protection systems, providing a unique human body model -based development and assessment framework. With respect to a wide range of relevant accident scenarios for mixed traffic, the aim is to address the challenges posed by demographic changes and ageing population, and future vehicle interior designs with new occupant sitting positions, etc.

The ongoing **AWARE2ALL** [76] project aims to explore how passengers will sit in highly automated vehicles (HAVs) and what activities they will engage in. Activities will also focus in investigating how HAVs will navigate through heavy traffic and interact with different road users also proposing a common conceptual universal safety framework for considering Human Machine Interaction (HMI).

72 http://www.dreams4cars.eu/

73 https://roadview-project.eu/

74 https://www.events-project.eu/

75 http://www.osccarproject.eu/

76 https://cordis.europa.eu/project/id/101076868

Higher levels of automation require a specific focus on the human-machine interaction, in particular on handing over the driving task between automated and manual driving which may be opportune in the event that the limit of the ODD is reached. The functional interaction between automated vehicles and the driver must be designed in a safe and intuitive way in terms of task division as well as with respect to the minimum time required to resume manual control.

HMI solutions should ensure transparent communication between the vehicle, the driver and the other road users in order to clarify responsibility for the driving task and avoid mode confusion. These objectives can be supported by the harmonisation of key HMI aspects which should be based on the results of R&I studies for higher levels of vehicle automation. In this context, the HADRIAN[77] project addresses the driver's role in Connected and Automated Vehicles by developing a holistic driving system solution, focusing on the utility of dynamically adjusting human-machine interfaces that take environmental and driver conditions into account.

Freeing the driver from the need to be regularly coupled to the vehicle controls, effectively becoming a passenger in the autonomous vehicle, increases the risk of experiencing motion sickness which can also jeopardise driving performance in the event of taking back control of the vehicle; hence automated vehicles should minimise this risk by ensuring a smooth ride.

In terms of achieving of high-levels of acceptance and adoption of CCAM with a variety of different types of private and public vehicles, it is also essential to understand and optimise the on-board experience and overall satisfaction of all users in terms of comfort, well-being, safety and security. In this regard, the approach being taken by the BRAVE [78] project is to assume that the launch of automated vehicles on public roads will be successful only if a user-centric approach is adopted where the technical aspects go hand-in-hand with compliance in terms of societal values, user acceptance, behavioural intentions, road safety, social, economic, legal and ethical considerations.

Indeed, automation will add new opportunities and challenges in terms of comfort and on-board physical well-being. At the same time, automated public transport vehicles that do not require a human driver onboard will generate new challenges in terms of ensuring the safety of passengers and their protection from possible threats and unsociable behaviour e.g. criminal acts including assaults, harassment, vandalism, theft etc. while meeting new potential users' demands in terms of comfort and privacy.

R&I Actions and Expected Outcomes

Correspondingly, the specific R&I actions relating to "Vehicle Technologies" are the following:

- **Environment perception technologies for CCAM**

Robust and accurate environment perception is essential for highly automated vehicles. Vehicle environment and traffic scenario perception systems are required to enable the extraction of reliable information for real-time decision-making including sensor fusion. On-board sensor systems are available for partially automated driving for specific Use Cases and ODDs. Considering more extensive safety requirements going along with higher levels of automation and strong demand for multiple applications in less limited ODDs, there is need for significant further progress in innovation in environment perception technologies including in high-definition maps.

- **Safe and reliable on-board decision-making technologies**

Advanced on-board decision-making functionalities are required to handle the diversity of Use Cases in their respective operational domains while guaranteeing the safety, reliability and conformity of

77 https://hadrianproject.eu/

78 http://www.brave-project.eu/

future automated vehicles which will integrate complex in-vehicle systems-of-systems with advanced sensors, control and actuators, relying on extensive computational power.

- **Efficient, certifiable and upgradable functions integrated in the vehicle**

Aiming to provide the most recent and powerful advancements in software, data analysis and artificial intelligence to the automated and connected vehicles, the innovation cycles of hardware and software need to be decoupled, hence taking advantage of the imminent transformation of the in-vehicle control architectures and operating systems towards centralization and generic functionality, co-designing their interfaces and their integration in the cloud-edge continuum in a seamless, reliable and cyber-secure way.

- **Preventive and protective safety for highly automated vehicles**

To exploit the potential of CCAM in terms of improving the safety of the transport system as a whole, on-board systems need to anticipate risks reliably, prevent crashes and minimise the consequences of unavoidable collisions. Furthermore, provision of the required technologies must be accompanied by the development of suitable assessment tools for the newly developed prevention and protection systems while supporting the definition of standards as well as the potential needs for traffic rules adaptation.

- **Human Machine Interaction (HMI) development for on-board CCAM technology**

The design of vehicle technologies must focus on enhancing the acceptance by users and by other road users, and generating trust and reliance on automated systems through well-designed, user-relevant and informative human- machine interfaces which allow, amongst others, intuitive and seamless transfer of control between the driver and the vehicle, while also responding to the needs of all users. Research should also focus on developing recommendations for the commonality of HMI principles and harmonisation of safety-related HMI designs for highly automated vehicles. This includes HMI design principles for remote operators, addressing amongst others the issue of situation awareness.

- **Addressing User-Centric Development of CCAM**

As the driving task is gradually delegated to the car, and as shared mobility becomes increasingly accepted and practiced, understanding and optimising the on-board experience and overall satisfaction of users, particularly in terms of inclusiveness, comfort, well-being, privacy and security, through the user-centric design of future road vehicles will be paramount for the widespread adoption of CCAM.

On the basis of these R&I actions, the expected outcomes include:

- Determination of appropriate, accurate, robust, reliable, cost-effective sensor-suite compositions (enabling safe and reliable Connected and Automated Vehicles, in all conditions and environments, with expanded ODDs); ability to perform advanced environment and traffic recognition/prediction (supported by big data and digital maps with dynamic real-time information), limiting false or non-detections of threats, focusing on VRUs; improved data fusion with infrastructure-based sensing and other vehicles; standardisation mandate for performance requirements.

- Capacity to determine the appropriate course of action in an open-world context with a wide range of traffic scenarios, respecting traffic rules; ability to perform state prediction to take timely actions and prevent activation under unsuitable conditions; determination of the required control system performance and quality/quantity of data needed to describe complex traffic scenarios, considering also human behaviour, with remote software updates.

- Reliable technologies for advanced safety systems to prevent crashes or minimise the consequences of unavoidable accidents, including improved minimum risk manoeuvres;

protection systems designed for unconventional seating positions and body postures, ensuring inclusiveness, considering all situations/conditions while taking into account different crash configurations in mixed traffic; consistent design methodologies and tools for performance assessment of the new protection systems; evidence-based support to regulatory bodies for the potential adaptation of traffic rules.

- Advanced HMI and HTI (Human-Technology Interaction) solutions enabling the safe, efficient co-existence and interaction of Connected and Automated Vehicles in mixed traffic (VRUs included); reliable, seamless interfaces, which are easy to understand, based on comprehensive knowledge and models of human behaviour/capabilities; monitoring systems and simulation models to assess/predict driver status; improved HMI functionalities to prepare the driver to take control (e.g. when the vehicle nears the ODD limit) and facilitate safe remote operation.
- Vehicle technologies and solutions which assess/optimise the on-board experience in terms of well-being, security and privacy, with improved design, ensuring inclusiveness and preventing dangerous/uncomfortable situations; training and information campaigns.
- Co-designed e-architectures and operating systems ensuring decoupled upgradeability of hard- and software for the simplified control of connected and automated to provide harmonized safety functionalities in extended ODDs, increased energy efficiency of the control system and predictive maintenance features.

Timeline

All planned R&I actions of this cluster start early on. The actions advance during the CCAM Partnership timeline towards testing and implementation in Cluster 1. Expected outcomes will also support the Validation activities and facilitate the Integration of the vehicle in the transport ecosystem as well as defining requirements for key enabling technologies. Innovation Actions will follow and advance technical maturity and progress the state of the art after the first phase, delivering mature results ready for testing/implementation. The following image aims at making this progression process transparent

Cluster 2

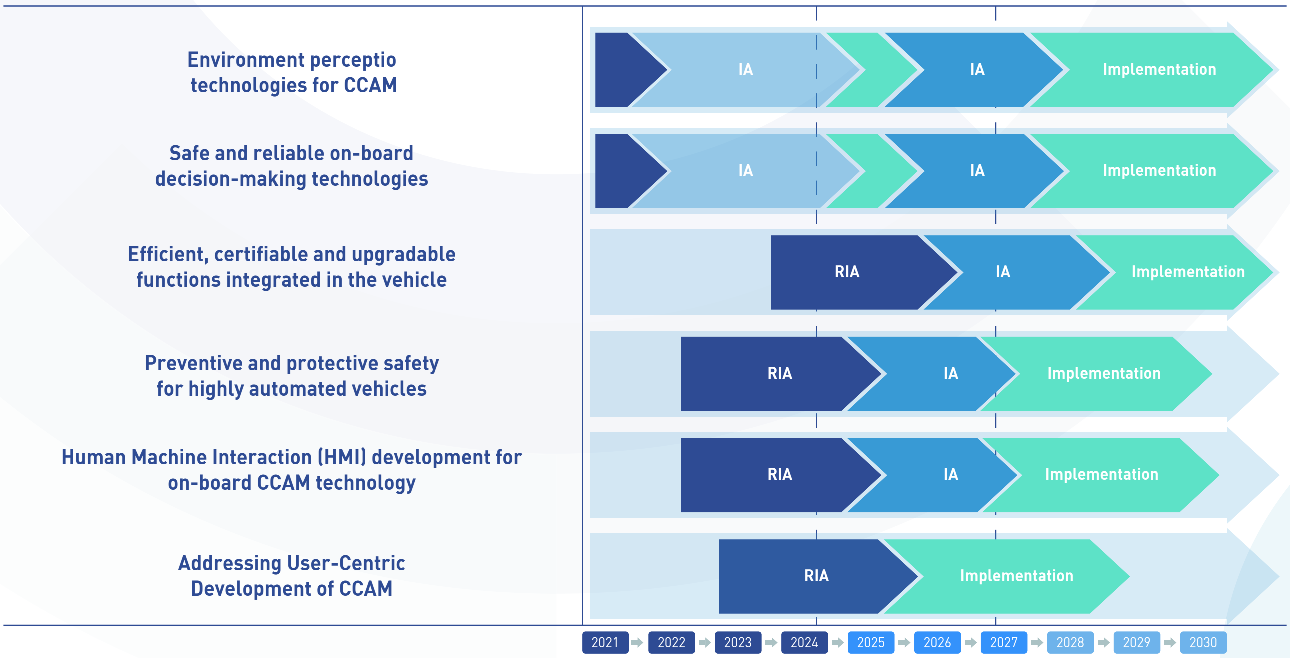


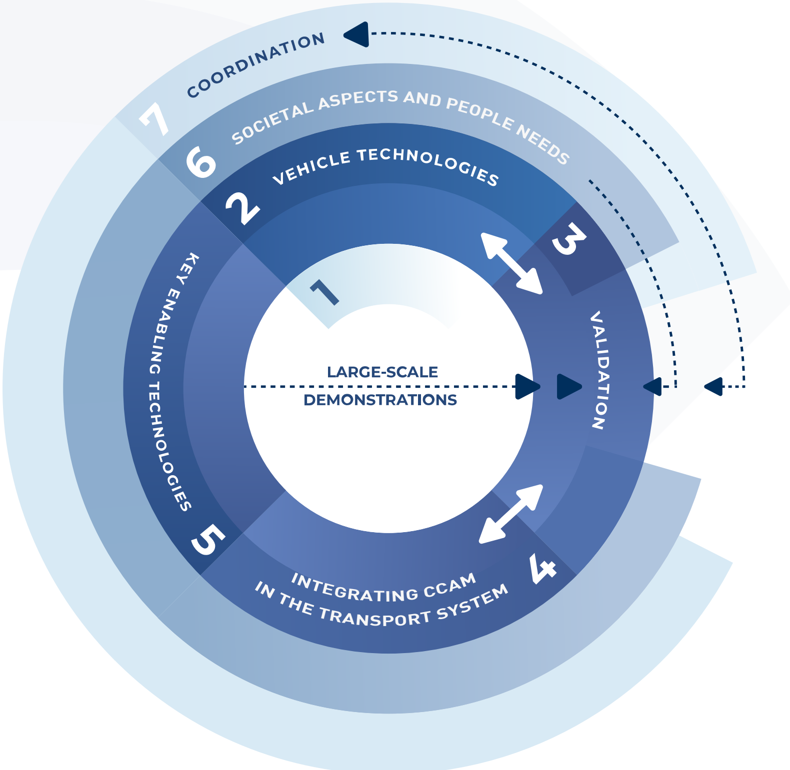
Figure 13[79]: Cluster 2 R&I Actions over the Partnership Programme timeline.

79 RIA: Research and Innovation Action; IA: Innovation Action. For details: see chapter 8.1.

9.3. Cluster 3: Validation

Introduction

The successful implementation of CCAM depends mainly on its acceptance and adoption in society. The decisive factor will be assuring the effective safety of CCAM. Therefore, the validation of the vehicles' automated driving functions and of their operation in the intended ODD is forming an important cluster in the portfolio of activities of the CCAM Partnership.



Cluster 3 will provide

- Validation methods applicable and recommendation of validation maturity necessary for FOTs and Living Labs, as described under "Large-scale demonstrations" above (to Cluster 1).
- Validation methodologies for application to vehicle technologies (to ensure the safe operation of CAVs and enable societal acceptance) (to Cluster 2).
- Enhanced methodologies and tools for integrating validated CCAM in the transport system (to Cluster 4)
- Requirements for validation methodology for cyber-security including protection against tampering of CCAM systems (to Cluster 5).

Higher levels of automated driving require scenario-based validation methodologies following hybrid approaches with physical and virtual testing. This is necessary to reduce the high number of test kilometres needed for safety validation specifically with more complex ODDs. The key R&I action in this cluster, "Future-proof methodologies and tools for validation", addresses this need and also considers the possibility of updates of hardware and software during the whole vehicle lifecycle as well as self-learning capabilities of future automated driving systems. Validation in operation is an important aspect, also in view of the ageing and performance degradation of systems on the one hand and the perspective of lifetime compliance on the other hand. Next to the safety of the intended functionality, this R&I action addresses the functional safety of such systems and will incorporate the results from cluster 5 with regard to the validation for cyber-security including protection against tampering. The R&I action "Future-proof methodologies and tools for validation" reflects the need to move more and more from a vehicle-centric perspective towards validation from the perspective of the transport system, including a multitude of other road users and the relevant infrastructure with its changes over time. While the focus is on validation for safety and security, this R&I action is open to address additional effects of CCAM, e.g. on traffic flow, which is facilitated by the adoption of this system perspective. It also includes the development of a commonly accepted and harmonised simulation environment for the virtual testing of CCAM functions and systems in their connectivity context.

A challenge for scenario-based validation will be identifying and considering all relevant critical scenarios with their criticality and probability of occurrence. This challenge is addressed by another R&I action in this cluster aiming at the establishment of an "EU wide database of relevant scenarios for validation". The scope of this R&I action covers the derivation, definition and collection of safety-critical scenarios for CCAM systems and their sharing as a basis for the verification, validation and assessment of CCAM systems in industrial development processes, in future type approval schemes and in consumer testing campaigns (like Euro NCAP). The action will build upon the "Future-proof methodologies and tools for validation" and will also make use of the "Test data exchange framework" from cluster 7 as well as the "System architecture for data sharing" from cluster 5. At the same time, the EU wide database of relevant scenarios for validation will be linked to the "EU wide knowledge base" to be developed in cluster 7.

Validation will also need to take in into account human factors. This applies to human-technology interaction as well as to the understanding of human driving performance as a reference for the CCAM systems' performance in reducing the number of fatalities and crashes. A specific R&I action developing a "Human reference for automated driving" validated by real-world tests will serve the latter purpose. Such a reference model of the performance spectrum of human drivers will allow a direct comparison to an automated driving system in the simulation of a specific situation and thus support the deployment of the results from the R&I action "Future-proof methodologies and tools for validation". Together with results from cluster 6 on societal and people needs, it will also form the basis of developing a common understanding of the required safety and reliability level of CCAM and support the definition of an acceptable behaviour of automated driving functions in mixed traffic. The human reference model should be used in validation of CCAM by including driver behaviour as a parameter of scenarios in the EU wide database of relevant scenarios for validation. Taking into account human factors into validation methodologies would not only be beneficial for high levels of automation but would also strengthen the safety validation of lower levels such as ADAS.

Since safe human-vehicle interaction is an important element of the safety of highly automated driving systems, there is also a need for harmonised HMI designs as well as harmonised HMI testing and validation, which is addressed by a fourth R&I action in this cluster on "Specific HMI testing and validation procedures, methods and tools for higher levels of automation". This applies both to driver-vehicle interaction and to the interaction with other road users, for which new intuitive interaction principles will be needed, when the human driver is not involved in the control-loop of the vehicle. This R&I action will profit from close cooperation with the "HMI development for CCAM" in cluster 2 (to ensure that development and validation methodologies are aligned) and complement the results from the R&I action on "Future-proof methodologies and tools for validation".

Advancing the State of the Art

While different assessment methods have been worked on for automated driving functions, and a mix of different homologation methods has been proposed, to date no common standard methodologies exist that meet all the requirements for testing, validation and certification of all levels and Use Cases of automated driving. The discussion on this is on-going regarding EU type vehicle approval rules as well as in the framework of the UNECE (WP.1 and WP.29). The HEADstart [80] project has analysed existing approaches and developed harmonised scenario-based methodologies and tools for verification and validation with a specific focus on positioning and communication technologies as well as on cyber-security. Building on the results of HEADstart, the SUNRISE [81] project is currently developing an extensible safety assurance framework for the testing and validation of CCAM systems, implementing a suitable simulation framework and preparing the required tools for comprehensive virtual and physical testing.

80 H2020 project funded under grant agreement ID 824309; https://www.headstart-project.eu/

81 https://ccam-sunrise-project.eu/

Several national and European projects have already started to collect relevant scenarios for verification and validation and store them in databases. Database structures and related methodologies have been defined and implemented on the national level. A sharing framework for aggregated test data and a common data format for EU wide application have also been developed, amongst others by the L3Pilot project. There is, however, no EU wide database of relevant scenarios nor an agreed database structure. The Hi-Drive project is contributing to the further harmonisation of scenario descriptions and, building on the results of L3Pilot, collecting additional data under different traffic, weather and visibility conditions. Validation and verification scenarios can be derived from that data in order to extend ODDs. Still, there is the awareness that not all future critical scenarios are already known nor possible scenarios induced by automation, and processes and tools for their continuous collection need to be established.

Regarding the "Human reference for automated driving", statistical data is available on the number of road crashes, injuries and road fatalities in many countries, which can be related to the number of person kilometres travelled to get an idea of overall human driving, vehicle and infrastructure performance in terms of safety. Statistical evidence, however, is missing on the performance spectrum of human drivers in the variety of specific situations which might be critical for automated driving systems. Several software modules to simulate human driver behaviour do exist today, but they only cover specific aspects of human driving performance and do not cover the full spectrum of drivers with statistical data on the probability of certain behavioural patterns. With a focus on modelling under uncertainty, the i4Driving [82] project is laying the foundation for an industry-standard methodology to establish a credible and realistic human road safety baseline for the virtual assessment of CCAM systems. The BERTHA[83] project is developing a probabilistic driver behavioural model to be implemented on an open-source repository to validate its technological and practical feasibility. Very significant additional efforts will be necessary to develop a fully validated and robust reference model of human behaviour depicting the performance spectrum of human drivers in critical situations.

The HMI design of highly automated vehicles is the subject of several R&I projects at the moment, addressing challenges such as those arising from mode transition situations. Although there is an agreement on the need for harmonised HMI designs for such vehicles and safe human-vehicle interaction is an important element of driving safety, there are no commonly accepted HMI testing and validation procedures, methods and tools available yet for higher levels of automation.

In addition to R&I, also regulatory activities on the validation of CCAM systems have been initiated, on the international level notably in the framework of the UNECE Working Party 29 on Automated/Autonomous and Connected Vehicles (GRVA). Representatives of members in the CCAM Association are taking part in relevant UNECE meetings, thus making sure that R&I in the CCAM Partnership is aligned with the current state of discussions at UNECE. The EU is a pioneer in this regard with the European Commission implementing regulation (EU) 2022/1426 on highly automated, driverless vehicles. This is duly considered and reflected in this updated SRIA. The regulatory framework, for example, already foresees remote operation in the sense of an authorised person outside a driverless vehicle requesting its automated driving system to perform specific manoeuvres in particular situations. In contrast to that, remote driving would imply an operator taking full control and driving the vehicle directly through a dedicated interface, for instance to have the vehicle out of the way. The validation of such remote driving remains a research issue addressed in this SRIA update. UN Regulation R155 delivers uniform provisions concerning the approval of vehicles with regards to cyber security and cyber security management systems, but does not consider a verification testing methodology to confirm the effectiveness of the cyber security applied to the vehicles. The definition of standard test cases would further improve the cyber security of highly automated vehicles in particular.

82 https://i4driving.eu/

83 CCAM project funded under grant agreement ID 101076360

R&I Actions and Expected Outcomes

The specific R&I actions relating to "Validation" are the following:

- **Future-proof methodologies and tools for validation**

  Common methodologies and tools (physical, virtual and hybrid) need to be developed to enable the verification and validation of CCAM systems in industrial development processes, in future type approval schemes and in consumer testing campaigns. This must consider maintenance, updates and upgrades of both software and hardware during the whole vehicle lifecycle and includes the development of a commonly accepted and harmonised simulation environment for the virtual testing of CCAM functions and systems. Advances in simulation tools and virtual models for realistic simulations are also needed, including digital twins. More and more, validation methodologies need to consider the context of the transport system, i.e. the interaction with other road users and the physical and digital infrastructure in the respective ODD. This will allow, amongst others, the validation of effects on traffic flow as well as the validation of coordinated CCAM and remote management concepts, including remote driving.

- **EU wide database of relevant scenarios for validation**

  Future methodologies for the validation of CCAM systems will make use of scenario-based approaches. The scope of this R&I action covers the definition and collection of safety-critical scenarios for CCAM systems with their level of criticality and risk of occurrence, their sharing in an EU wide database and the derivation of test cases as a basis for the validation of CCAM systems in industrial development processes, in future type approval schemes and in consumer testing campaigns. The database shall be updated continuously and also reflect critical scenarios derived from in-service monitoring and reporting. Moreover, virtual simulations of road traffic need to be better understood as a source for the generation of relevant future scenarios for validation.

- **Human Reference for Automated Driving**

  A fully validated and robust reference model of human behaviour depicting the performance spectrum of human drivers in critical situations will allow a direct comparison to an automated driving system in simulation and form the basis of developing a common understanding of the required safety and reliability level of CCAM including well-founded acceptance criteria. By not only representing an average driver behaviour, but covering the full performance spectrum, it will be possible to quantify the performance of an automated driving system in a specific situation in comparison to the human driver population. The reference model can then also be integrated in validation procedures and enable the inclusion of human behaviour as a parameter in validation scenarios.

- **Specific HMI testing and validation procedures, methods and tools for higher levels of automation**

  Highly automated vehicles will need Human-Machine Interfaces (HMI) which allow intuitive and seamless transfer of control between the (on-board or remote) driver and the vehicle within short time as well as safe interaction with other road users. With the shared use of different vehicles becoming more common, and drivers / other road users having to adapt to the internal / external HMI of different vehicles, commonality of HMI principles and harmonisation of safety-related HMI designs will be needed as well as their harmonised testing and validation.

On the basis of these R&I actions, the expected outcomes include:

- Common methodologies and tools defined, accepted and validated
  - by the CCAM value chain and its R&I partners for the efficient verification of CCAM systems in their R&I and product development processes,
  - by authorities and certification bodies for the validation of CCAM systems within type approval schemes and in future exemption procedures,
  - and by consumer testing campaigns for the safety rating of automated vehicles assisting users in identifying the safest choices for their needs.
- Verification, validation and rating procedures based on realistic and relevant test cases generated from an openly accessible and continuously updated EU wide database, providing the widest possible range of relevant scenarios which CCAM systems will potentially encounter on EU roads as a basis for robust system design.
- Extension of verification, validation and rating procedures to (self-)learning CCAM systems to maintenance, (over-the-air) updates and upgrades of hardware and software during the whole lifecycle of vehicles and infrastructure components as well as to coordinated CCAM and remote management including remote driving.
- Inclusion of the connectivity context in the verification, validation and rating procedures for CCAM systems which rely on connectivity for safety-critical functions, taking into account the aspect of cyber-security.
- A validated, robust and scalable reference model of human driving behaviour:
  - Replicating the full performance spectrum of human drivers, which allows comparing the performance of an automated driving system in a specific situation to the human driver population. This serves as a basis to define the required safety level of CCAM systems and to take decisions on validation requirements (acceptance criteria) in type approval schemes. The model will also help to define fair assessment criteria in consumer testing campaigns relative to human- driven vehicles and for the safety verification of CCAM systems in industrial development processes.
  - Serving as a reference for the automotive industry and its R&I partners to design human-like and therefore easily predictable and acceptable behaviour of automated driving functions in mixed traffic.
  - Applicable in virtual validation, verification and rating procedures and thereby helping the automotive industry, its R&I partners, certification bodies and consumer testing organisations to realistically represent the behaviour of other human-driven vehicles in the (virtual) simulation of mixed traffic. Virtual testing shortens development cycles and accelerates the implementation of CCAM technologies.
- Harmonised methods and tools for the testing, verification and validation of the internal and external HMI of highly automated vehicles defined and accepted by the CCAM value chain and its R&I partners as well as by authorities and certification bodies. These methods and tools will be based on common HMI principles and harmonised HMI designs.

Timeline

The first three R&I actions of this cluster are planned to start early on. The actions in Cluster 3 will advance during the CCAM Partnership timeline towards implementation, particularly in Cluster 1 and in Cluster 2.

While future-proof methodologies and tools for validation will already become available from a RIA in the first phase of the CCAM Partnership, another RIA is foreseen to follow and to extent methodologies and tools for validation to self-learning CCAM systems as well as to over-the-air updates of CCAM functions during the whole vehicle lifecycle. Moreover, the connectivity context will need to be included for future CCAM systems relying on connectivity for safety-critical functions.

The EU wide database of relevant scenarios will need to be updated and extended continuously according to extending ODDs and to the emergence of new traffic scenarios in the future road transport system.

The R&I action on a human reference for automated driving will also deliver valuable results in the first phase of the CCAM Partnership by providing a human behavioural model validated for selected fields of application. Expanding these fields towards a fully validated human reference model replicating the full performance spectrum of human drivers in all relevant situations, however, will definitively require another RIA building on the results from the first phase.

Research on specific HMI testing and validation procedures, methods and tools will start as an integral part of a RIA on future-proof methodologies and tools for validation. Based on common of HMI principles and the harmonisation of safety-related HMI designs from Cluster 2, another RIA on related testing and validation procedures, methods and tools will complete this research in the third phase of the CCAM Partnership.

See Figure 14: Cluster 3 R&I Actions over the Partnership Programme timeline. showing this progression process.

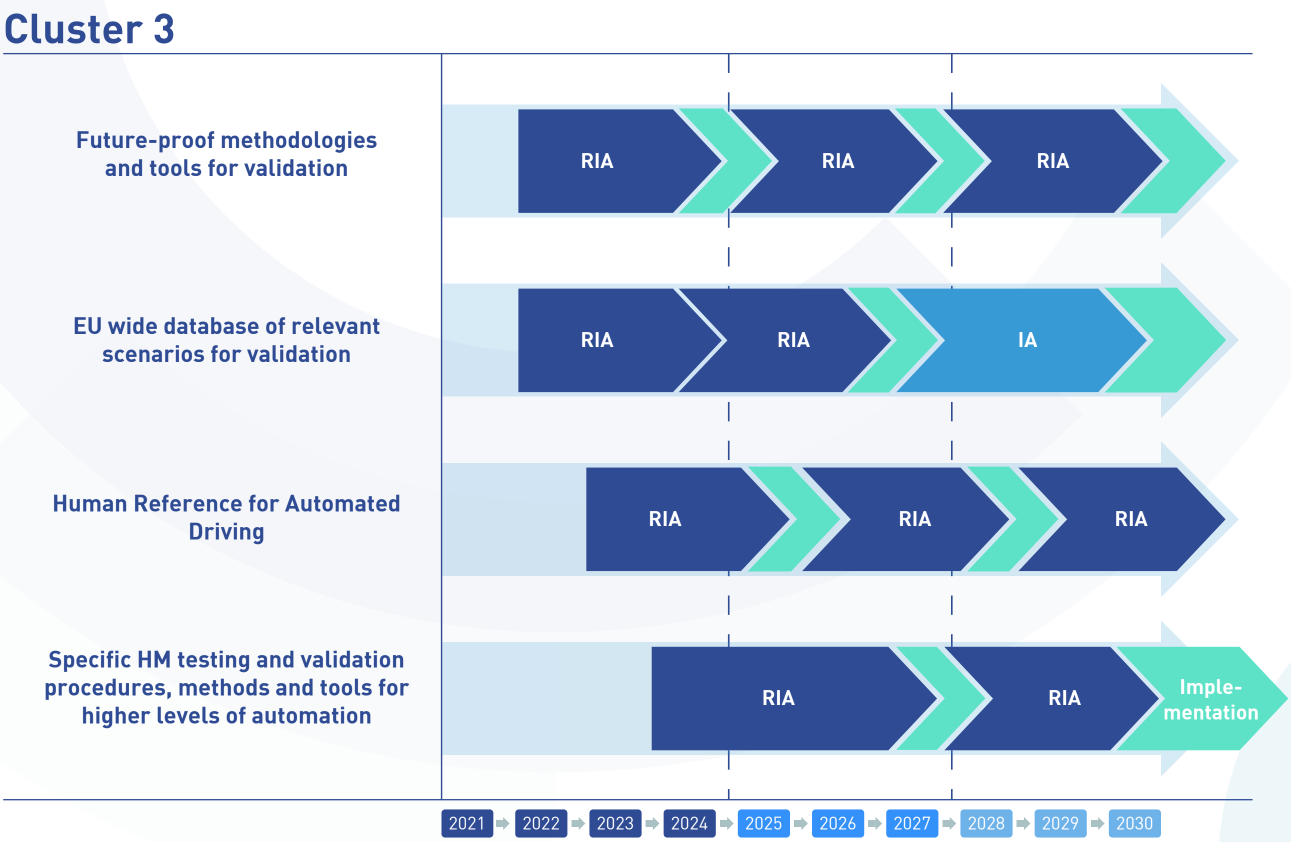
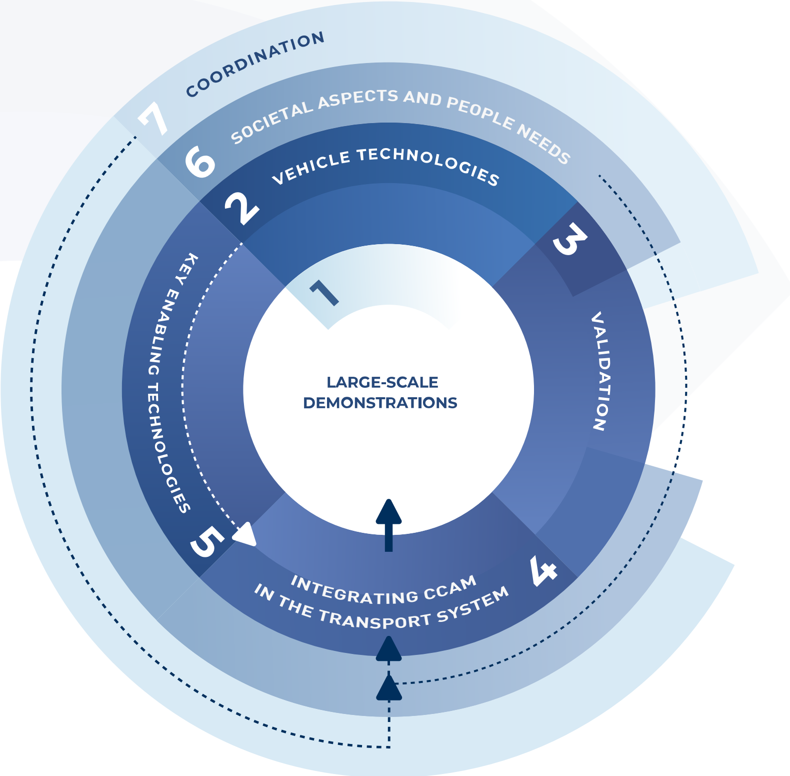


Figure 14: Cluster 3 R&I Actions over the Partnership Programme timeline. showing this progression process.

9.4. Cluster 4: Integrating CCAM in the transport system

Introduction

The integration cluster plays a pivotal role with regard to the goal of the CCAM partnership – to create more user-centred, all-inclusive mobility, while increasing safety,



reducing congestion and contributing to decarbonisation. Connected Automated Vehicles represent an integrated part of the future effective and efficient Mobility System, interacting with their environment, humans and other – old and new – transport means. Connectivity and automation are closely linked to each other for a coordinated and unified approach towards introduction, as outlined in the Declaration of Amsterdam (see chapter 8.4 on the role of the States Representatives Group).

Cluster 4 will:

- Provide digital information from all road transport operators and actors incl. private and commercially used individual vehicles to enable automated vehicles in mixed traffic (to Cluster 1).
- Develop connectivity and communication solutions to be integrated in vehicle technologies for sensor fusion, supporting on-board decision making, and enabling new HMI and active safety solutions (to Cluster 2).
- Provide transport system context (incl. infrastructure) for validation purposes (to Cluster 3).
- Deliver approaches and requirements regarding connectivity and communication towards cyber security or data sharing (to Cluster 5).
- Provide feedback on people needs and societal expectations (to Cluster 6) and further coordination needs (to Cluster 7).

The cluster finds itself at the crossroads of different mobility sub-systems, requiring integration steps taking a system of systems perspective on mobility management (including sustainability and planning aspects as well as road safety and human factors). Interaction with infrastructures (road and telecommunication infrastructure, automotive backends as well as the mobility services and the accompanying infrastructure) is crucial for the success of the system integration. Elements of physical, digital and operational infrastructure are important, in particular building a common understanding of what is required, how it can be achieved, and which roads should be prioritised with a view towards implementation. To prepare for the integration of maturing technologies, research in all clusters needs to encompass advances on methodologies, tools and applied safe and secure technologies, as well as governance and architecture issues. With regard to longer investment cycles of road infrastructure and budgetary processes of public actors, there is a challenge to identify no-regret infrastructure investment in support of enlarging and optimising (e.g. robustness, predictability, uninterrupted coverage) Operational Design Domains (ODD) for CCAM vehicles. Moreover, all of these aspects call for harmonisation towards an EU definition of CCAM (incl. its system elements, i.e. vehicles, different infrastructures) and the CCAM ecosystem. Guiding principle for the integration of CCAM into the mobility system is the service point of view. As services are characterised by underlying value propositions, the integration cluster has to address the needs and requirements of actors such as private vehicle users, public authorities and public transport operators and logistics operators. Even in a system-of-system's perspective, there are distinct sub-domains embracing individual vehicles services, shared vehicles services and logistics services. To better explain the integration process of vehicles in the transport system, the aspects of connectivity and interoperability need to be further highlighted. Connectivity represents an important capability of Connected and Automated Vehicles, expecting to increase the safety and efficiency performance of automation functions. Interoperability is key for providing seamless mobility, most notably at locations where handovers between infrastructure operators (e.g. urban – interurban road network, cross-border, Mobile Network Operators) are needed and between transport operators and service providers. Besides the connectivity aspect, cross-sector harmonised message sets based on standards are needed for communicating C-ITS information and also triggering actions of and between vehicles (e.g. cooperative manoeuvres, negotiation of intentions). Furthermore, Connected and Automated Vehicles may not necessarily be driven as an individual object in a swarm (traffic flow) but to an increasing extent becoming part of a managed fleet operated in the mobility system. Although differing in operational aspects, from traffic management perspective, the task of fleet management and orchestration is independent from which actor takes this role (e.g. service provided by fleet management, individualised or semi-collective recommendations from traffic management) and whether a fleet is shared or mixed in modes.

A specific element with regard to safe operation of Connected Automated Vehicles which has grown in importance is remote management (as currently proposed as top-level term), comprising a.o. remote assistance and remote driving. This element requires research and innovation across clusters as it can deliver benefits to several CCAM domains and related use cases such as automated shuttles and car sharing, hub-to-hub Heavy Goods Vehicles transports and delivery bots. The investigation of a number of issues related to, but not limited to, support requirements, functional safety, human-machine interaction, validation, in-service monitoring of ADS capabilities, key enabling technologies, labour market aspects, roles and responsibilities would accelerate the technological and societal readiness of remote assistance and remote driving. Obviously, the R&I needs do cut across clusters (most notably clusters 3, 5 and 6) while the element itself resides in the integration cluster.

Advancing the State of the Art

- The R&I actions of this cluster, i.e. extending fleet and traffic management for CCAM, physical and digital road infrastructure, communication infrastructure, connectivity and cooperative systems, can build on important achievements of research projects, related standardisation activities as well as regulatory and policy initiatives. In a generalised view the achievements on which the CCAM partnership builds on are as follows:
- The first generation of C-ITS services (Day 1 services) and their underlying message sets have been successfully developed, tested, standardised and profiled, piloted at large scale in Europe and have found their way into deployment.
- First concepts and messages for next generation services which go well beyond sharing information only, aiming at e.g. predictability of driving manoeuvres and transition of automation levels (incl. Transition of Control (ToC) aspects), have been studied and have been instrumental to standardisation work.

- Many of the CCAM services and Use Cases can benefit from 5G communication. A first set of projects and cross-border trials has looked into validating advanced 5G features such as New Radio, Mobile Edge Computing, Network Slicing, roaming techniques, O-RAN, Non-Terrestrial Networks etc. Terrestrial Networks are the enabler for the deployment of the next CCAM services. Non-terrestrial Networks shall be explored as a complement to 5G terrestrial networks to enable seamless CCAM services in a future deployment timing. The seamless handover has to be addressed in order to provide an acceptable experience for CCAM services. Based on the findings from R&I and pilots, an early wave of actions for 5G systems deployment along transport corridors has been formed recently, supported by the CEF Digital Programme. Besides the application to the "vertical", it is also necessary to inform about CCAM requirements towards the development of 6G as the next generation of mobile communication, driven by the Smart Networks and Services Joint Undertaking.
- It is commonly understood that road infrastructure support can benefit the sense-plan-act-process of CCAM enabled vehicles. Relevant elements of physical, digital and operational infrastructure have been identified. How infrastructure can provide assistance to CCAM enabled vehicles has been developed and studied and is still ongoing.
- Mixed traffic, comprising automated and conventional vehicles as well as including the interaction with mobility users, poses several challenges. Road safety and transport efficiency as well as suitable modelling tools, automation ready infrastructure and automation ready road authorities have been studied and are still being addressed in R&I. Studies have found so far important contributions to the goal of the CCAM partnership while indicating conflicts in goal achievement which are attributable to the mixed traffic configuration and the multiplicity of the needs to be addressed (e.g. safety and efficiency).
- Improved collaboration within and across sectors also require shared knowledge, common tools and federation mechanisms to achieve superior performance on shared goals. Support actions have strongly enhanced the knowledge base, stimulated the collaboration tools and mapped out mechanisms which can serve as blueprints for the goal of the CCAM partnership.
- Many projects have delivered important inputs to the evolution of (multi-part) standards, e.g. DATEX II, TPEG, METR, cooperative ITS messages such as CAM, DENM, IVI, CPM, etc. In order to take full advantage of standardisation achievements, the uptake and possible harmonisation of standards in R&I, testing and piloting should be pursued.
- Moreover, the CCAM partnership is embedded in a policy and regulatory environment in favour of CCAM, mobility integration and data sharing, e.g. ITS Action Plan and ITS Directive, C-ITS Strategy, CCAM Strategy, Data Strategy, type approval of the ADS of fully automated vehicles. It is useful that R&I activities address aspects needed for a controlled and harmonized EU-wide CCAM implementation (such as listed in the MVWG-ACV paper on policy topics, comprising a.o. enforcement and data collection on the safe use of ADS, see chapter 3.1 on regulatory actions). Involving actors like police, emergency services and insurers provide valuable insights that can facilitate deployment and operation of CCAM services.

R&I Actions and Expected Outcomes

The specific R&I actions relating to "Integrating CCAM in the transport system" are:

- **Physical and Digital Infrastructure (PDI)**

  PDI improves CCAM services and enhances their performance by extending the operational domains as well as increasing functional safety and traffic efficiency. EU-wide and global harmonisation is key to define necessary infrastructure support for CCAM, enabling broad market uptake of services and guaranteeing coordinated deployment and a single market based on complementary Operational Design Domain (ODD) and infrastructure support.

- **Connectivity and Cooperative Systems**

  Hybrid communication approaches based on a technological neutral definition of connectivity and communication between vehicle and all elements of the transport system enable information exchange, realising collective perception and therefore enable cooperative automated mobility. In the expected mix of CCAM vehicles and conventional traffic this ensures the smooth and safe coexistence of connected cooperative automated vehicles and all other road users (specifically vulnerable road users) and enables better driving functions and increased traffic efficiency.

- **Fleet and traffic management in a CCAM eco-system**

  CCAM has to enable a system that orchestrates traffic management sub-systems, where people and goods will have to move within a continuous and cross-border framework of services that are interoperable (inter-modal interfaces should also be included). It is essential, that both fleets (commercial/logistics fleets, fleets operated by public or private transport operators) and individual vehicles (CCAM- or conventional vehicles) are well integrated in the entire traffic management system. This comprises planning, forecasting and managing the movements of each single vehicle according to its specific needs and under mixed traffic conditions. Fleet and traffic management utilises new and updated tools of operational infrastructure in CCAM support for instance to mitigate the risks due to transfer of vehicle control between ADS and human driver or to supervise ADS in potential edge cases with possible loss of ODD.

On the basis of these R&I actions, the expected outcomes include:

- Common understanding of requirements and minimum set of infrastructure adaptations for the physical, digital and operational infrastructure for CCAM systems and services, in mixed traffic with conventional vehicles and other road users and modes of transport, responding to the specific requirements of each traffic context.
- Description and development of service architectures of PDI for CCAM systems and services and agreed classification of infrastructure support levels stimulating EU-wide/global harmonisation for classification of infrastructure support.
- PDI support concepts of proven maturity (technically, functionally, etc.), developed in cooperation with road users and vehicle manufacturers to extend their Operational Design Domains (ODD) and provide ODD awareness to automated driving systems, and ready for large-scale demonstration actions.
- Simulations and testing to investigate how PDI can support CCAM and which are the effects on traffic efficiency, traffic safety and traffic management (e.g. identification and performing of minimum risk maneuver).
- Business and financing models, policy options and ways to increase competencies and resources for road authorities, operators and traffic managers ensure physical, digital and operational infrastructures remain fit for purpose.
- Connectivity and cooperation enablers and needs for higher levels of automation identified and assessed, based on a detailed Use Case-approach for the CCAM mobility system.
- Requirements for availability (e.g. coverage, security) and performance of connectivity and cooperation enablers (e.g. data rates, latency, interruption time, robustness and redundancy,

quality of service, resilience against cyberattacks) specified per CCAM Use Case, meeting requirements of functional safety and safety-critical applications.

- Ensured quality of and trust in external data by common definitions (incl. quality indicators definition) meeting requirements of cross-border interoperability and continuity.
- Feasible and sustainable concepts for and provision of road infrastructure coverage of connectivity and positioning along the road network developed to enable CCAM services, included in testing at living labs and ready for large scale demonstration.
- Integrated perspective and recommendation for actions on co-design, co-investment, co-existence, co-management and co-performance of connectivity and communication systems.
- Concepts of fleet and traffic management in the CCAM eco-system that go beyond digital twinning enabling optimised (and/or optimisable) systems for the mobility of people and goods and are well integrated with existing urban / regional mobility environments. The technological levers (What is possible with CCAM?) address and balance societal and people needs (What can and what should CCAM solve?).
- Interfaces that enable interoperability between traffic management systems (of different geographical locations and/or of CCAM vehicles and other modes of transport) considering integration beyond road transport in the overall multimodal transport system providing seamless mobility services.
- Advancement and evaluation of CCAM enabled mobility services to identify their market potential. Identification of the necessary adaptations of the mobility service solutions and their framework conditions.
- Addressing urgent CCAM development needs to realize quick wins for the societal benefit. As a system-of-system's approach these analyses need to consider the different maturity of CCAM Use Cases regarding distinct sub-domains embracing individual vehicle services, shuttle services and logistics services.
- Digital and operational infrastructure and related tools needed for the remote fleet management operation of ADS to ensure the road safety and traveller security in automated private and public transport vehicles (including robo-taxis, delivery vehicles, public transport shuttles).
- Advanced simulation models and tools that enable and help planning, designing and assessing traffic management strategies (including dedicated lanes, priorities at intersections etc.) and demand management strategies enabled by CCAM.
- Optimised mobility network load balancing approaches through advanced traffic management guidance and information loops that can reach individual users as well as operational traffic and fleet management actors.
- Effective cooperation and governance models for operating CCAM services as part of real-life fleet and traffic management systems developed and tested.
- Harmonised approach for creating unambiguous and objective rules of the road (digital versions of national driving codes, traffic orders, mandatory traffic management measures etc.). Digital driving license for ADS should be developed.
- Support requirements, functional safety, human-machine interaction, in-service monitoring of ADS capabilities, roles and responsibilities (e.g. information needs of tele-operators, latency effects compensation, switching between roles, technology confidence and expertise formation) of remote assistance and remote driving.

Timeline

All planned R&I actions of cluster 4 start early. The actions advance during the CCAM Partnership timeline towards testing and implementation in Cluster 1. Expected outcomes of the first actions (AUGMENTED CCAM, PoDIUM, CONDUCTOR, IN2CCAM) will allow for implementing specific elements after the first phase of the CCAM Partnership.

At the same time it is expected that R&I actions of the technology clusters (Cluster 2 and 5) will deliver important results on e.g. improved sensor and in-vehicle decision making capabilities as well as how cybersecurity can be best embraced in order to allow and achieve a transport system integration of vehicles, infrastructure, user and overarching entities. These inputs, including progressing the state-of-play on core R&I topics of Cluster 4 itself, will stimulate a second wave of Innovation Actions. This wave aims at advancing the technical maturity and putting more emphasis on the organisational implications of the proposed solutions, all to drive the integration of vehicles in the transport system. The second wave targets on delivering mature results ready for testing and implementation in the final third phase of the programme. The following image aims at making this progression process transparent.

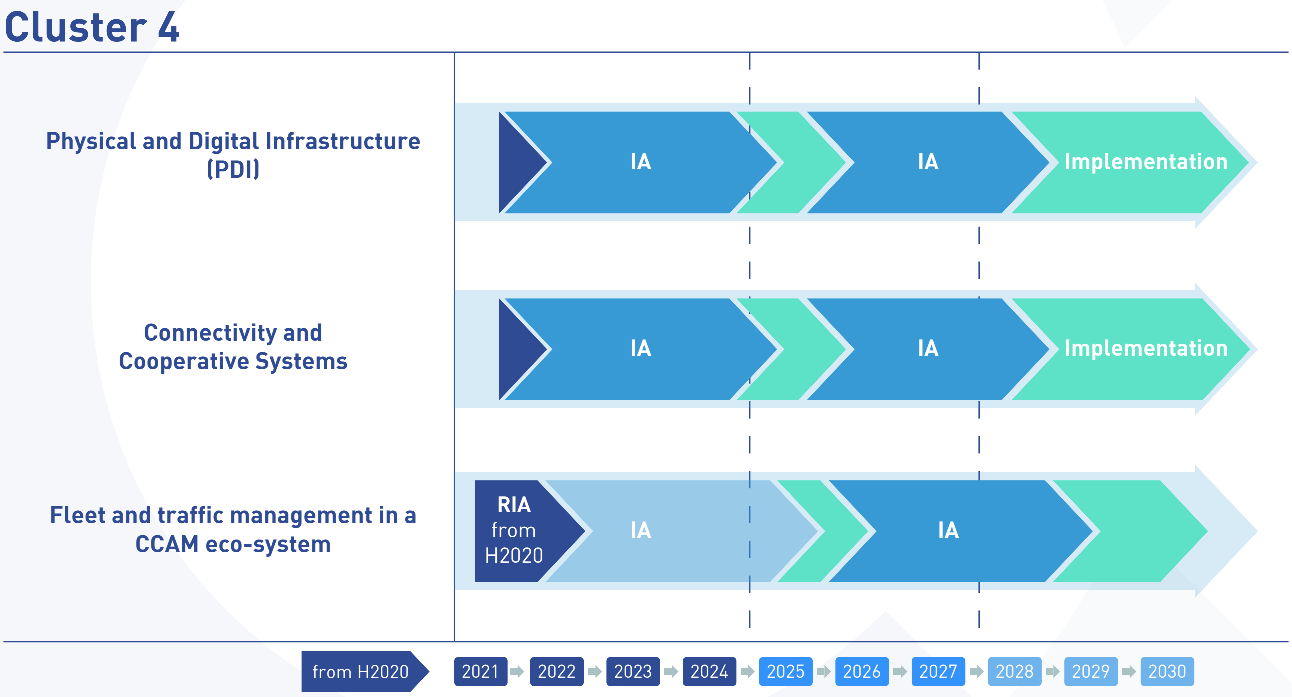
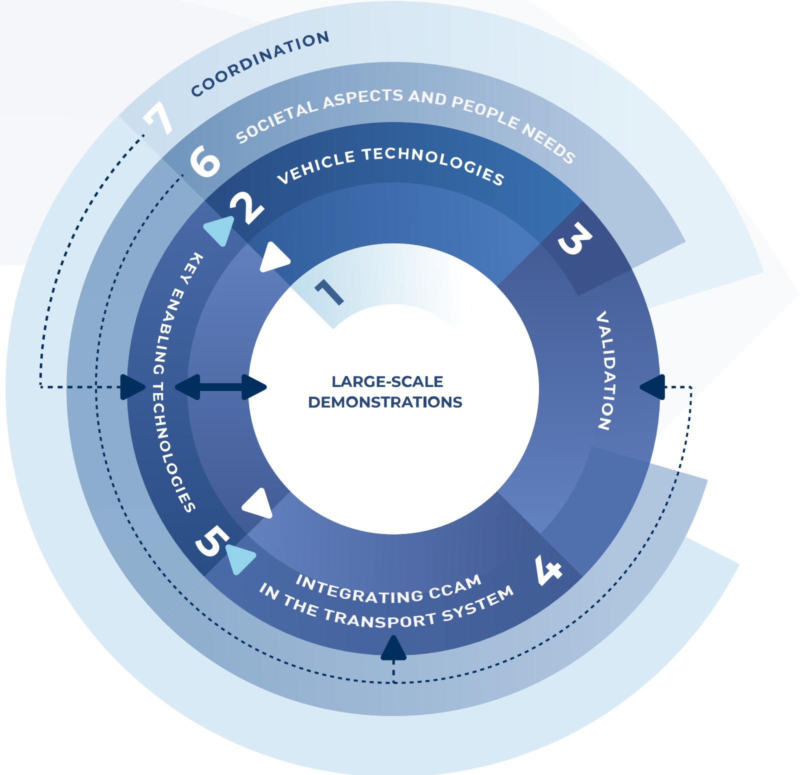


Figure 15: Cluster 4 R&I Actions over the Partnership Programme timeline.

9.5. Cluster 5: Key Enabling Technologies

Introduction

This Cluster focuses on CCAM R&I actions on enabling technologies, driven by digitalisation and extending the application of these technologies beyond the individual vehicle in a system's approach. In case of e.g. AI, it has the capacity to go way beyond on board decision making, based data from in-vehicle sensors. Data from other vehicles, infrastructure and back offices can be used in



decision making in complex scenarios including safety critical situations, ranging up to traffic management, emission management, charging of vehicles and provision of many new and emerging mobility services.

Thus, the Cluster fosters cooperation amongst stakeholders from several technology areas and industries. Safe and secure operation of vehicles and mobility systems is key to develop trust and establish user adoption of CCAM solutions.

This Cluster 5 will

- Provide AI and cybersecurity solutions to be integrated in vehicle technologies (related to environment perception and on-board decision making) (to Cluster 2).
- Develop harmonised procedures, methods and tools for the validation of cyber security for inclusion in conceptual description of an approval scheme of CCAM systems (to Cluster 3).
- Provide the basis for validation methods and tools for AI applications in CCAM for integration in validation procedures for CCAM systems (to Cluster 3).
- Develop and/or integrate Key enabling technologies (e.g. secure communication, robust and resilient connectivity, edge computing) contributing to better performance of vehicle-transport system integration (to Cluster 4) and of in-vehicle technologies integration in the cloud-edge continuum.
- Elevate the possibilities for synergies with stakeholders, also beyond originally mobility focused partners, using enabling technologies to take a systems' perspective in road mobility and CCAM Technologies.

A harmonised approach to further develop these technologies can help to reduce market fragmentation, currently hindering EU companies to fully benefit and exploit new mobility business cases based on CCAM. For this, the extended domains are addressed with R&I actions for cybersecurity, information and data sharing and artificial intelligence (AI). Advancing CCAM solutions and developing a common understanding of well-functioning CCAM under all circumstances will certainly benefit from harmonising approaches for data sharing (aligned with the EU Data Act), whilst on the other hand leading to maximised societal benefits of the technology application. Harmonised approaches for data sharing, leading to a system architecture for data sharing, should be developed for the full range of product development stages from development, testing, and validation up to implementation.

With these developments, it is important to differentiate data from information, in which the latter is a dataset collectively carrying a logical meaning.

As data and information sharing is advancing, it is essential to include data security and cybersecurity requirements complying with European regulation (The Data Governance Regulation) regarding privacy, data security and cybersecurity. Fragmentation of data sharing approaches would lead to lack of seamless mobility possibilities, duplication of data storage and huge data inefficiencies, lack of coherence.

Extending the system domains beyond the vehicle through connectivity (short range or cellular) makes cybersecurity a fundamental building block for trusted (digital) interaction of road users with each other, the infrastructure and cloud-based solutions/services. CCAM technologies will more and more use data from multiple sources, and will need the capabilities to integrate this data. Cybersecurity needs to be made an integral part of the development process, with common aims and objectives, frameworks/architectures, and designs (including normal operation, decision making and actuation as well as anomaly detection). Furthermore, it should lead to the advancement and development of new solutions for assessing resilience at distributed and at a system level. These techniques are needed to enhance vulnerability detection and robustness of CCAM system. The target will be to develop tools and methods to detect and mitigate all possible attacks and their cascading effects in the CCAM system. Improved AI-based cybersecurity attack detection to in-vehicle networks, with more precise identification and attack attribution, and potential response will require major actions, needed to ensure safe and secure operation. Connectivity will to an increasing extent use new solutions, like 6G when it's deployed wider; joint actions with the SNS Partnership can help to take a coherent approach here.

AI has a huge potential to change the (in-vehicle) decision making process as well as new services or safety solutions supported by AI, especially when a systems' approach is taken. AI has to become a functional competitive and affordable CCAM technology first, in order to support safe autonomous driving in a more complex and dense traffic environments. Specific automotive requirements such as safety, security and real-time functionality demand dedicated AI development for CCAM applications. This will have to go hand in hand with human centric AI developments, delivering guidance on Explainable AI, notions of fairness, and on AI and human interaction, ethics and legal issues. Implementing AI for situational awareness, in particular in CCAM, presents a variety of challenges, e.g. industrialisation, requirement-based development, continuous improvement of trained modules for application in safety critical domains. Verification of AI for situational awareness is essential for CCAM to operate in more complex urban traffic scenarios. The ambition is to move from reactive and/or adaptive system support to AI based predictive system state awareness, decision making and actuation. AI based joint learning approaches for CCAM technologies can bring accelerated improvements.

Advancing the State of the Art

Digitalisation is an ongoing development in almost all European sectors, also having a clear impact on the CCAM developments, testing, validation, implementation and operations As such, the effects of digitalisation go beyond the well-established digitalisation in e.g. development processes in automotive. This is reflected in the developments regarding the software defined vehicle (SDV), in which software to an increasing extend is shaping the vehicle customer experience, offering adjustments to the driver's needs and a potential for constant optimisation of the vehicle.

To make use of the benefits the advancing levels of digitalisation can offer for road mobility, the sector faces major challenges in adopting Artificial Intelligence (AI), Big Data (BD), communication technologies and availability, cybersecurity, and Edge/Cloud Computing. It requires the adoption of models that parallelise and iterate development and operations (DevOps) on a continuous basis, particularly applied to hybrid cloud/backend and edge infrastructures involving Machine Learning processes (MLOps). Consequently, there is a clear need for efficient and cost-effective smart distributed and semantically aware processing tools and a flexible software infrastructure allowing distributed processing (edge/cloud) for data discovery, collection and processing alongside the product lifecycle, which match the constantly growing amounts and varieties of data.

Data plays a crucial role in the AI development and testing. Automated driving requires billions of test kilometres and huge amounts of data, generated through real and simulated test drives. Instrumented vehicles, equipped with cameras, lidar, radar, GNSS/IMU, etc. and with ADAS sensors, gather raw information. The processing of this data to create information will permit its use in the AI pipeline. However, AI-related data management is a complex challenge, mainly due to the heterogeneity of data types, integration of real and synthetic data, coexistence with iterative AI development and operation cycles, and storage and computational costs. Furthermore, unknown sets of non-acquired data can widely influence the correlations created by AI and ML processes, thus producing negative effects in final data driven systems. Data sharing approaches so far are merely limited to project or pilot base, or limited to specific use or Use Cases. For implementing connected, cooperative and automated mobility on a larger scale, including the essential further R&I activities, data sharing (as a key element of the DevOps approach) needs to be established on a wider scale and in an harmonised approach. Serving as a basis for next steps in R&I activities are the best practice examples for test data sharing as they have been developed and reported in the projects L3Pilot, Hi-Drive, ARCADE, SUNRISE and FAME, as well as 5G-Mobix. Inputs from Cluster 7 are needed here. Cross project sharing will be an important first step; initially of data sharing frameworks and architectures, later on also on the actual data sharing and storage. An explicit cooperation will exist with activities within Cluster 1 on large-scale testing as well as with Cluster 4 especially on Connectivity and Cooperative Systems. The activities here should be seen in the light of e.g. Common European Data Spaces and the expected Data Act and take this to the contextual application.Cyber security is often discussed and researched in a general approach. Explicit translation and implementation of results towards the specific CCAM domain needs to be achieved. Research can build upon previous work e.g. the CEN-CENELEC Cyber Security Focus Group. For CCAM, contextual definition is needed, including sector specific security features. This can build further on the recently developed UNECE WP.29 R155 and R156 regulations and ISO/SAE 21434 standard on a structured process to ensure that cyber security is included upfront in the system (vehicle or infrastructure) design. The SECREDAS ECSEL project offers a referential starting point for more sector specific work, while looking at the operational security. The SELFY Project (CL5-2021-D6-01-04) is developing a toolbox made of collaborative tools with the aim of increasing the security, protection and resilience of the CCAM ecosystem against cyber-attacks. Links are included also to Cluster 3 on e.g. v2x communications and validation of over the air updates and programming of vehicles, in a cyber secure approach. Alignment and cooperation is needed with Cluster 2, especially Safe and reliable on-board decision-making technologies, as well as for issues like over air updates of in-vehicle technologies.

CCAM solutions have benefited from the applicability of AI-based perception, situational awareness (outside traffic and inside driver state), and decision-making components. Current state of the art within AI has a primary focus on vehicle state. However, first steps have been made to incorporate information and predictions also regarding human (driver) state (AWARE2ALL project) and system state (the projects EVENTS and ROADVIEW) regarding the environment around the vehicle, including object classification in perception technologies.

The AITHENA and AI4CCAM projects are advancing towards trustworthy AI exploring trade-offs among other equally important properties: robustness, privacy, explainability, accountability, and ethics. The

CONNECT project, working on creating fundamental building blocks of a trust modelling framework for CCAM, adds other essential parts to the tool sets available. These new properties play a key role in supporting the public acceptance of open source software for non-critical parts, ánd AI based CCAM technologies and their market uptake, as well as in boosting the essential societal benefits.

Adapted testing mechanisms for trustworthy-AI need to be defined for homologation procedures. These mechanisms shall be compliant with the Data Act and AI Act and firmly address the recommendations of the AI High Level Expert Group and their Guidelines for Trustworthy AI [84]. In addressing this, close interaction between Cluster 5, Cluster 2, Cluster 3 and Cluster 6 will be needed. Overarching developments like the creating of the software defined vehicle are building on these steps and inputs.

AI development and evolution consists of two main steps: training, (teach the algorithm with labelled data), and application (apply the learnt mechanism to newly unseen data). New advances in training like Federated Leaning should be further explored to optimized centralized cloud base training with a smart distribution of the training task across several computing nodes, each of them managing local data, and merging the multiple trained models. Thus, federated learning can facilitate compliance with the principle of data minimization. Inference phase will depend on the (edge) target HW. The implementation of real time self-contained AI functions in the edge (vehicle, infrastructure) is paramount in CCAM specially for critical safety related functions where driving context and decision making needs to be performed without the latency of a cloud transmission. Advances in Edge AI model optimisation, minimizing model energy consumption is required.

The Partnership aims to go beyond static AI systems by moving to adaptive system support and up to AI based predictive system state awareness, decision-making and actuation. Data fusion needs enrichment with also high precision localisation, end-user information, infrastructure (sensor) data as well as system state information, while balancing interactions. Major steps can be made in the broad implementation of CCAM solutions with AI components, for passenger vehicles, logistics providers, traffic management systems and new mobility service offerings, taking an explicit multimodal systems approach. The work within this context can build partially on projects within the framework of the Partnership AI, Data and Robotics and the EC funded project AI4EU. Within the CCAM Partnership, close interactions are foreseen with Cluster 2 especially on environment perception technologies for CCAM, and safe and reliable on-board decision-making technologies.

To enable remote management, real time transmission and display of high quality video, sensor data and commands are required. This imposes new challenges to communication technologies where the latency, bandwidth and communication channel reliability will be of paramount importance Communication link needs to be available and predictable (availability and availability conditions) and should be part of the ODD definition. As such, IoT technologies play a significant role in the implementation of CCAM services and applications. IoT can provide and enrich CCAM services with the integration of road infrastructure information and with other information that can have an impact on the CCAM services (weather conditions, accidents, traffic flows, crowded areas, proximity of vulnerable road users…). Thus, there is a need for research on IoT technologies for communication, sensing and, in particular, precise positioning and tracking, and on intelligent sensors and actuators that can help to generate better contextual information for the development of future CCAM services and applications.

84 Ethics guidelines for trustworthy AI, 8.04.2019, https://ec.europa.eu/digital-single-market/en/news/ethics-guidelines-trustworthy-ai

R&I Actions and Expected Outcomes

The specific R&I actions relating to "Key Enabling Technologies" are the following:

- **Cybersecure components and systems**
  Systems for CCAM enabled mobility will have to be fail-operational and cyber-secure in their entire Operational Design Domains (ODD), to guarantee a safe and secure operation of vehicles and systems. Both safety and cyber-security need to be considered in a systems perspective, also as they are related to the interaction of vehicles as well as with the infrastructure, transport management systems and service systems. Joint definitions of the targeted levels of safety and security will be needed, as well as harmonised methods and protocols for its validation, to be included in e.g. future type approval schemes, for these systems as separate technical units.

- **Robustness and resilience**
  Highly automated vehicles will need consolidated robustness and security measures. Threats, failures, problems as well as malicious and unintended interactions will have to be detected real-time and fed to a decision-making process on response actions. A tool suite of appropriate actions is needed to enable the component or system stepping back in real-time to a safe and secure situation. Improved AI-based cybersecurity attack detection to in-vehicle networks, with more precise identification and attack attribution, and potential response will require major actions, needed to ensure safe and secure operation.

- **New explainable concepts and training of AI for CCAM applications**
  There is a firm need for explainable, trustworthy [85] AI for CCAM applications and scalable solutions, including a clear vision on the capabilities and limitations of the AI systems and AI blocks management. Concepts, techniques and models of AI for CCAM need to be developed and trained, with a first application in safety critical domains. Sufficient breadth and suitability of training data, solutions for data documentation (e.g. verifiability of data used for training), robustness and accuracy need to be incorporated. New AI approaches are to be further developed, reducing the data requirements. The new AI approaches include e.g. federated learning approaches for CCAM, edge AI and edge/cloud communication. Major improvements are to be expected in addressing user acceptance and in increasing societal impact of AI based CCAM solutions, as well as market uptake. Joint learning approaches in using AI for CCAM, but also the development and inclusion of notions of fairness in AI based tools is needed. There is a further need for approaches dealing with unknown sets of non-acquired data, and how these influence correlations, training and further implementation. Validation and harmonisation of digital tools including advanced AI technologies as EdgeAI is to be developed. This will further enhance efficient and cost-effective smart distributed and semantically aware processing tools and a flexible software infrastructure allowing distributed processing (edge/cloud) for data discovery, collection and processing alongside the product lifecycle.

- **AI for situational awareness**
  In contributing to the essential ambitions of Vision zero, AI based CCAM and intelligent collision avoidance systems should aim to reduce the number of accidents. In this sense, AI can help by using the data provided by all road users (including vulnerable) to predict trajectories and estimate the probability of collision, and to establish on board and collective situational awareness.
  For meaningful (human) control of autonomous systems, advanced AI approaches -including hybrid AI- will be needed: combining system and domain knowledge, learning from data with

85 ExplainableandtrustworthyAI:herewith,wemeansystemswhichactinaforahumanpredictableandsafemanner,whichactaccordingtoclearandpre- de- finedethical-goalfunctions.Theactionsanddecisionsdofollowanexplainablelogic,whichisinlinewithorveryclosetothehumandecisionmaking. As such, its actions are perceived safe, logic and comfortable; trustworthy. It will deliver technical solutions for CCAM implementation which can be easily acceptedand boostitsuptakeindaily-use,easingpotentialinclusivityhurdlesandmaximisingsocietalbenefitsofsuchAIbasedCCAMsolutions.

knowledge-based AI techniques in order to improve the overall system performance, including, when needed, control handovers and handbacks. For increasing levels of automation, coordinated and comprehensive use of AI for situational awareness is essential to estimate and predict the system state, state of the human occupant or driver, and traffic state; the three parts that together determine the safety of a situation. In advancing CCAM, AI will be used to make the next steps, from situational awareness to decision-making and actuation. To limit the latency and the energy consumption of AI models, edge computing (EC) and edge intelligence (EI) will play an important role. Moreover, EC and EI allow to mitigate privacy constraints, by avoiding sharing data in the network.

- **System architecture for data sharing**
  A harmonised approach for data sharing and data storage will be essential to allow for seamless, continuous operation by many actors (both from the vehicle side and the infrastructure) at the same time. This approach will incorporate items like data format, a common ontology for defining the terms, quality, speed, decisions on raw data vs data selections. It can help to build harmonised tools for processing data, combining inputs from multiple sources.

On the basis of these R&I actions, the expected outcomes include:

- Safe and secure operation of CCAM vehicles and mobility systems and services, enhancing trust and end user adoption of CCAM solutions.
- Cybersecurity requirements including data security and access control enabling harmonised approaches and tools for data sharing.
- Improved understanding of the new, emerging and specific CCAM related cyber security and resilience challenges, by using the contextual definition, including sector specific security features.
- Inclusion of cybersecurity and resilience as an integral part into the development process of CCAM solutions by OEMs, Tiers, telecom providers and service providers, with common aims and objectives, frameworks/architectures and designs
- Cybersecure data sharing approaches from pilot applications towards CCAM on a harmonised larger scale.
- Efficient and cost-effective processing tools and a flexible software infrastructure allowing distributed processing of data, as well as collection and processing alongside the product lifecycle.
- A joint and harmonised approach for data sharing and data storage, allowing for seamless and continuous operation of CCAM systems and services.
- Concepts, techniques and models based on Artificial Intelligence (AI) used for situational awareness, prediction, decision making and triggering of actions for time critical and safety relevant CCAM applications as well as for cyber threat detection and mitigation.
- A clear understanding of the capabilities, limitations and potential conflicts of AI based systems for CCAM- for the entire CCAM stakeholder community including the end users, and strategies for joint learning approaches using AI, speeding up uptake and reducing development times..
- Increased user acceptance and societal benefit, from an early stage, based on explainable, trustworthy and human-centric AI. Interactions with AI using vehicles should be understandable, human-like and reflect human psychological capabilities, including notions of fairness.
- Application of advanced AI technologies for CCAM facilitates e.g. the systems' approach and

systems' optimisation, striving for climate friendly applications.

- Accelerated AI development and training for CCAM enabled by a relevant set of real and synthetictraffic events and scenarios.
- AI based CCAM solutions will evolve from reactive and/or adaptive system support into predictivesystem state awareness (including driver state and user diversity), decision-making and actuation,enhancing road safety especially in near-critical situations.

Timeline

The Cluster 5 actions all follow a logic of a step-wise approach: moving from development on a component level (mostly in RIAs) to integration into system approaches and adjusting to needs of specific Use Cases or user groups (in IAs) ultimately to application and implementation.

The first two R&I actions within Cluster 5 are planned to have an early start, with the earliest planned implementation. The third and fourth R&I actions are planned to start in the second and third year, as these actions will advance based on inputs and needs from Cluster 2, 3 and 4, with a close link to Cluster 6 for especially the R&I action on Explainable AI. The last R&I action will have its start pending on results of projects within Cluster 7 on test data sharing.

Innovation Actions will follow and advance technical maturity and progress the state of the art after the first phase, delivering mature results ready for testing/implementation. The following image aims at making this progression process transparent. As the Actions in Cluster 5 concern fairly new technologies in the application domain, the sequence of RIAs, IAs and implementation is expected to run throughout the running time of the Partnership. Based on inputs and needs from Clusters 1, 2, 3, 4 and 6, detailed (R)IA needs and implementation paths can be defined. In the same way, new key enabling technologies can arise from other sectors, for inclusion and implementation here.

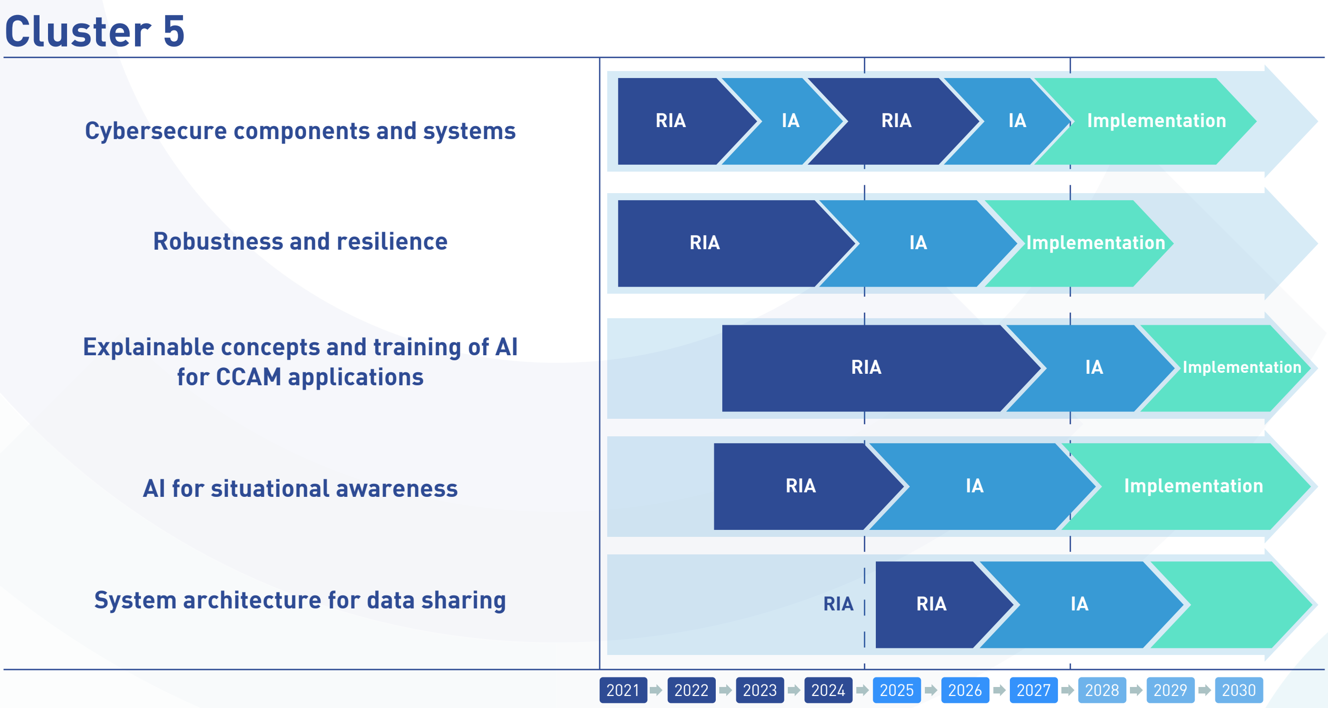
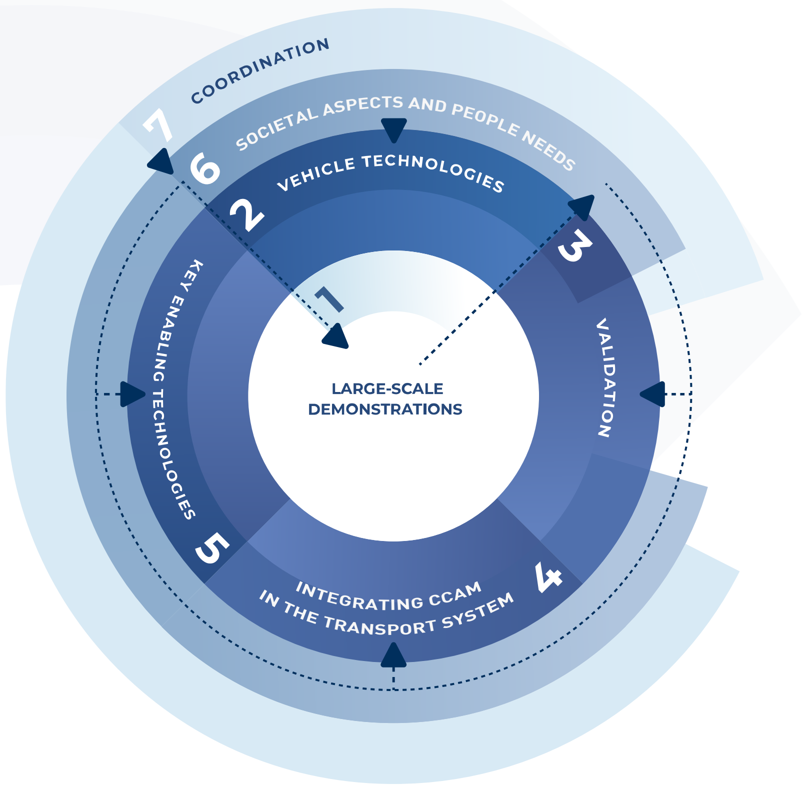


Figure 16: Cluster 5 R&I Actions over the Partnership Programme timeline.

9.6. Cluster 6: Societal aspects and people needs

Introduction



It is widely understood that the successful deployment of CCAM depends largely on the societal benefits it can generate and on adoption by users. "Users" is to be understood in a wide sense: it includes individual users of CCAM services and of the wider transport system but also communities, commercial actors and other organisations that are involved in the mobility of persons and goods. To achieve the desired benefits, CCAM development, deployment and regulation have to be based on a well-founded and genuine understanding of the societal context, specific needs, impacts (positive as well as negative) and costs. Taking into account the full range of users, as well as societal aspects, is a prerequisite for offering CCAM services that are relevant, appreciated, acceptable, and most appropriate for serving social, economic, and environmental needs and objectives. Not to be forgotten are road-users that potentially could be affected by the CCAM-mobility services, but not currently taking a direct role in them.

Cluster 6 will:

- Provide input on societal and people needs for the right setup of Large-scale Demonstrations, requirements on studies; what needs to be tested to verify adoption; and to confirm societal expectations in Living Labs (to Cluster 1).
- Deliver people and societal needs for input to accessible solution development (to Cluster 2) and validation (to Cluster 3).
- Provide the user perspective and societal needs to develop and guide overall transport system integration and effects on sustainable land-use (to Cluster 4).
- Provide societal needs and concerns to be addressed while developing and adapting Key Enabling Technologies for CCAM (Cluster 5).
- Give feedback on societal aspects in co-creating Living Labs for evaluation methodologies (to Cluster 7).

Actions in this cluster will investigate, in the widest sense, the needs of the European society at large, of citizens, organisations and CCAM users, and how CCAM can play a role in meeting those needs.. Methods and measures will be developed for capturing these demands as well as the expectations, desires and concerns towards CCAM, considering that they may change over time. The evolving societal context will be assessed in order to understand how CCAM and associated services can positively contribute to societal targets for decarbonisation and environment, such as the Green Deal, as well as for equity, safety, accessibility, land use and urban structures. The benefits of CCAM for different types of users in a variety of settings -within but also outside urban areas – including the conditions for achieving them as well as direct and indirect costs in the short, medium and long term – need to be understood, handled and transferred into the CCAM development process. Methods will be developed to adequately assess the socio-economic impacts and to address interdependencies of effects in different timeframes. CCAM developers, deployers and public authorities will be provided with tools to implement people-centred solutions that effectively contribute to the societal targets and the adoption of CCAM systems and services at regional level.

Furthermore, the workforce consequences of higher degrees of automation and digitalisation in CCAM road transport will be analysed, taking a holistic view on mobility and which professions may be affected. The requirements for new or adapted skills and educational programmes will be defined. In addition, the need for enhancing organisational capacity within local government will be explored, in terms of transport management, planning and policy making, to ensure the public sector has up to date knowledge for dialogue with CCAM service and solution providers.

Advancing the State of the Art

The uptake of CCAM relies on attractive, meaningful offers that address people and societal needs. These needs have to be understood in CCAM offers, using broad and highly integrated methodologies, which can be empirical. They have to go beyond technical aspects, and enable society to reach targets on decarbonisation and climate change. Vision Zero – i.e. no road traffic deaths, and ambitions to increase equity, and to reach prosperity and profitability, are other examples of societal needs that CCAM deployment should be designed to support. There is a growing understanding that CCAM services should not limit themselves to the vehicle and infrastructure that allows the transport of persons or goods from point A to point B within as well as outside metropolitan settings, but should also ensure that the full purpose of the trip can be achieved.

While demonstrations involving members of the public or stakeholder engagement have been ongoing for some time; user and societal aspects for higher degrees of automation are being explored (e.g. SHOW, Hi-DRIVE, MODI, AWARD, ULTIMO, KIRA [86]) and are being further developed by two Horizon Europe projects starting in 2022. SINFONICA [87] will develop strategies, methods and tools to engage CCAM users, citizens, service providers and other stakeholders to collect, understand and structure their needs, desires, and concerns related to CCAM in a manageable and exploitable way. MOVE2CCAM[88], will engage with citizens across its three prototypical regions to co-create CCAM use cases that respond to their mobility needs. MODI is also engaging users (e.g., logistic actors) in investigating key barriers and drivers for using automated transport for logistics.

Co-creation with potential end-users or non-users of CCAM services as well as with deployers – primarily cities/municipalities, regions and passenger transport authorities/operators – is highlighted as critical for successful CCAM implementation [89]. Large-scale participatory processes targeting future users, citizens, and specific groups need to be established to identify their needs and to involve them in subsequent design and development processes. SINFONICA will provide specific recommendations and guidance for large-scale demonstration projects.

Compared to vehicle and technically-oriented efforts, aspects related to inclusiveness and equity are far less common in CCAM design or R&I, and rarely go beyond considering persons with reduced mobility,

86 https://www.deutschebahn.com/de/presse/pressestart_zentrales_uebersicht/Weltpremiere-Autonome-On-Demand-Fahrzeuge-im-normalen- Strassenver-kehr-10397970?view=&contentId=6900954

87 https://sinfonica.eu/

88 https://move2ccam.eu/

89 The Societal Readiness Thinking Tool: A Practical Resource for Maturing the Societal Readiness of Research Projects: https://link.springer.com/arti-cle/10.1007/s11948-021-00360-3

gender, and age groups, or vulnerable road users (for a gender example, see the Horizon 2020-projects DIAMOND [90] and VI-DAS [91]; for an example on vulnerable road users, see the recently started Horizon Europe project AWARE2ALL [92]). A few projects have started to look at CCAM opportunities in rural environments [93] [94] although this remains an under-researched area. Persons with different income levels or different digital experiences are additional examples of user groups that need to be included to reach a more all-encompassing analysis of needs and expectations, whether at a micro or macro level. To foster inclusion, the SINFONICA project recommends using inclusive language, that also shows respect for different gender identities, in any discussion with citizens.

Equity is expected to be further advanced by projects responding to the Horizon Europe topic HORIZON-CL5-2023-D6-01-04: Integrating European diversity in the design, development, and implementation of CCAM solutions to support mobility equity.

Deployment of CCAM will generate impacts, positive as well as negative, which have to be known and handled. Balancing these effects can be seen as one societal need. The prospect of generating profitable business is one of the drivers for CCAM. However earlier promises made, eg, by robotaxi companies, about operating large fleets of vehicles without drivers by the early 2020s have fallen well short. Research indeed reveals that shared mobility is emerging slowly[95] due to economic, instrumental, affective, symbolic, tax-revenue, governance and administrative reasons. A consequence is that investors interested in more short-term gains are reported to be considering switching interest towards less-complex, less cash-intensive forms of autonomy with a clearer path to payback, operating at lower speeds with little to no traffic [96].

Moreover, policy makers and planning professionals are exhibiting a reactionary rather than pro-active attitude towards CCAM deployment. While the societal impact of CCAM is the subject of research, there are few practices and research for translating such knowledge into concrete planning, policy and governance guidelines opening up the way for real-life implementations. Mobility as a Service (MaaS), including business models, needs to be included and must move beyond available validated methodologies for impact measurement of existing technologies. Several impact assessment frameworks and KPIs, as well as supporting tools are available from e.g. SIMOD [97] Levitate [98] and PAV[99] . Efforts to elevate methodologies from surveying or interviewing into more extensive interactions in the form of citizens' dialogues and workshops (collaboration with Cluster 7), and integration of developments in living labs (collaboration with Cluster 1) need to make sure that the implementation side (municipalities, cities, regions) and service providers are involved.

Move2CCAM will establish a multi-systems network of actors across the whole CCAM ecosystem consisting of industries, authorities, researchers, and citizens that will be engaged through a series of co-creation activities, dialogues, social simulation experiments, virtual reality games, and AV demonstrations in eight European countries and at a pan-European level to collect data and specify the multisystem impacts of CCAMs. The project will furthermore co-develop through a series of workshops prototype business models with a wide range of organisations from the public and private sectors.

---

90 https://diamond-project.eu/

91 http://www.vi-das.eu/

92 https://cordis.europa.eu/project/id/101076868

93 https://www.drivesweden.net/en/project/roadmap-faringso

94 https://www.drivesweden.net/en/project/smart-landsbygd-autonoma-latta-transporter-landsbygdglesbygd-och-mindre-tatorter

95 Milakis, D., Seibert, D., 2023. The illusion of shared automated vehicles. Working paper. Institute of Transport Research, German Aerospace Center (DLR)

96 https://www.reuters.com/business/autos-transportation/investors-go-back-basics-with-simpler-self-driving-vehicles-2023-02- 01/?utm_medium=Social&utm_source=twitter

97 Krausea. J. et al: "Socio-Economic Impacts of Mobility Disruptive Trends" (2020)

98 Chaudhry, A., Thomas, P., Hu, B., Roussou, J., Gebhard, S., Weijermars, W., Veisten, K., Augustin, H., Zach, M., Ponweiser, W., Potts, L., Ziakopolous, A., Morris, A. (2022). Policy Recommendations for Connected, Cooperative, and Automated Mobility, Deliverable 8.4 of the H2020 project LEVITATE (https://levitate-project.eu/wp-content/uploads/2022/06/Levitate-D8.4-Policy-Recommendations.pdf)

99 https://northsearegion.eu/media/22099/pav-deliverable-social-impact-assessment-of-avs_final.pdf

These business models will be integrated with the economic assessment criteria of the Move2CCAM impact assessment tool.

Trust, privacy, and ethics are considered important factors to foster user acceptance of CCAM. CCAM within MaaS usually means involving some kind of shared or pooled on-demand passenger or goods transport – a theme that is addressed in several projects. To make such operations financially viable, it is necessary to remove the steward who typically is on board in current European pilots of self-driving vehicles. Ruter, the public transport agency in the Oslo region, has stated its ambition to implement steward-less autonomous vehicles. When such services involve "sharing", this in turn creates new aspects of acceptance, which is explored in the AutoMaas-project. Moreover, it is a question of aligning policies and plans for deployment of CCAM in cities with public transportation or MaaS, which is not yet the case [100].

The European Commission is making efforts to establish tools for assessing societal readiness and stakeholder involvement to prepare for the effective and responsible integration of R&I projects into society [101]. Ethical issues have been discussed in a report by a Commission Expert Group [102] and will be considered for the implementation of the CCAM R&I agenda.

High expectations on job growth (e.g. in the field of ITS) through CCAM are contrasted by fears of job losses through automation (for example for bus drivers). The Covid pandemic has aggravated the alleged shortage of commercial vehicle drivers. 2023 is designated as "European year of skills"[103], and the topic HORIZON-CL5-2023-D6-01-05 specifically calls for projects that address "CCAM effects on jobs and education, plans for skills that match the CCAM development, and prerequisites for employment growth". The full range of professions and roles involved in CCAM-related services for mobility, and the entire value chain are to be considered. Additionally, projects should develop actionable analyses capturing a larger scope and systems level to support the realisation of job growth aspirations and to enhance innovation capabilities.

R&I Actions and Expected Outcomes

The specific R&I actions relating to "Societal aspects and people needs" are the following:

- **Societal, citizen and user needs – for needs-based CCAM solution development and deployment**

  This action strives for a better understanding of needs, expectations and desires of future users, citizens, and society at large, inside and outside cities, taking into account decarbonisation, energy and resource conservation. The effects on CCAM of new societal trends, like the hybridisation of work, and new transport needs, habits and attitudes arising from the pandemic and associated policies, like lockdowns, should also be considered. This will be essential input into the design and development of viable CCAM services and solutions – as well as to policies - that can best serve these needs, without increasing equity gaps. "Avoid-shift-improve" transport should be considered.

- **Socio-economic and environmental impact analysis and target-based assessment of CCAM benefits**

  This action will lead to comprehensive impact assessment methods that cover the full range

100 Grindsted, T. S., Christensen, T. H., Freudendal-Pedersen, M., Friis, F., & Hartmann-Petersen, K. (2022). The urban governance of autonomous vehicles – In love with AVs or critical sustainability risks to future mobility transitions. Cities, 120. doi:10.1016/j.cities.2021.103504

101 Bernstein, M. J., Nielsen, M. W., Alnor, E., Brasil, A., Birkving, A. L., Chan, T. T., . . . Mejlgaard, N. (2022). The Societal Readiness Thinking Tool: A Practical Resource for Maturing the Societal Readiness of Research Projects. Sci Eng Ethics, 28(1), 6. doi:10.1007/s11948-021-00360-3

102 European Commission, Directorate-General for Research and Innovation, Ethics of connected and automated vehicles : recommendations on road safety, privacy, fairness, explainability and responsibility, Publications Office, 2020, https://data.europa.eu/doi/10.2777/966923

103 https://data.europa.eu/en/publications/datastories/towards-2023-european-year-skills

of effects of the full value chain of mobility systems and services involving CCAM, taking into account under-researched fields and groups. The ambition is to provide tools for using desired impacts as a key input in CCAM development and deployment, and thereby reach expected effects. These tools should be iteratively designed with the active input of the actual users in order to be effective and reliable.

- **Workforce development and knowledge enhancement**

  This action aims to define and assess opportunities to meet expectations on job growth through CCAM services' wider deployment. Activities might include the impact assessment of higher degrees of automation and digitalisation in road transport on the future workforce, new trends in working conditions and an analysis of requirements for workforce skills along the full value and educational chains.

On the basis of these R&I actions, the expected outcomes include:

- Detailed, robust and documented knowledge on planning, policy and governance transitions required for real-life implementation of CCAM systems and services. This includes, in particular, guidance on the extent, bundling and timing of required policy (e.g., about information provision, infrastructures, operations, services) and governance changes (e.g., about regulations, taxation, administrative structures) at national, regional and local levels for societally beneficial CCAM real-life integration.
- Detailed, robust and documented knowledge (e.g. knowledge maps) of citizens', users' and implementers' expectations, concerns and desires with regard to CCAM services and solutions for the mobility of persons and goods, with special attention to the needs of vulnerable users and under-researched groups. This knowledge is to be integrated into:
  - the design and development of CCAM solutions to support these specific needs.
  - educational and workforce development actions to enable delivery of services.
- A well-founded understanding of effects and impacts (positive as well as negative), benefits and costs of CCAM systems and services (short, medium, long-term), profitable business models, and how CCAM can support the Green Deal.
- KPIs incorporating societal targets with mobility needs for individuals, be it for their personal transport or for their goods. Methods and indicators to assess the impacts of CCAM solutions on mobility and wider socio-economic effects (public health, land use/infrastructure need, environmental aspects such as energy use, accessibility, air quality, carbon emissions and impact on economy, employment, working conditions and required skills etc.).
- Recommendations for large-scale demonstration projects of CCAM involving MaaS, to include user and societal aspects taking into account location-specific characteristics of the implementation area – which can also be beyond an urban setting, such as local policy targets, population density, and cultural matters.
- Methods and tools for CCAM developers and providers, public authorities, municipalities and citizens: These should enable service design, decision making, and implementation of user-centred solutions and business cases that effectively contribute to decarbonisation and the Green Deal, and other societal targets, including equity and inclusiveness, as well as the uptake of CCAM systems at regional level.
- Knowledge and understanding of the policy environment fostering CCAM business and labour market dynamism with incentives for increased investment from companies in human capital, supporting mobility and on the job training.

- Framework for building CCAM related awareness, knowledge and competence at all levels of society – from school curricula, training of persons in the entire mobility service value-chain, users, planners, decision makers in public and private contexts. Definition of short and long-term demands for updated skills and enhanced knowledge for the range of professions related to mobility services involving CCAM.
- Input for the design and evaluation of CCAM partnership activities, in particular for the large-scale demonstrators (ex-ante and ex-post), and for public engagement activities aimed at realistically informing users of CCAM capabilities and expectations.
- All the above expected outcomes should support the uptake and adoption of CCAM services and solutions, and CCAM's contribution to meeting societal targets.

Cluster 6 "Societal aspects and people needs" lays the foundation for understanding citizens' and society's needs and the expected impacts of CCAM, and interacts therefore with all other clusters. It provides input in terms of emphasising topics that need to be investigated in more detail to maximize the benefits to society. It also sets boundaries and informs the other clusters about potential unintended effects.

Timeline

Based on R&I actions for Needs and Impact Cluster 6will deliver to all clusters up-to-date and relevant input for the upcoming phases of the Programme: future users' needs to be taken into account, and socio-economic impacts for use in pro-active planning of clusters' actions.

Output from other clusters will create a wider view of needs and impacts through e.g. experiences from large scale demos and user centric solutions (Clusters 1,2) and Clusters 3, 4. Furthermore, new key enabling technologies (Cluster 5) and Cluster 7 activities will create new opportunities to understand and assess needs and impacts. The consecutive Cluster 6 RIAs on Needs and Impact will capture and handle both these inputs and the dynamic nature of CCAM, the continued deployment, updated set of stakeholders and their needs, societal evolution etc. Additionally, there is the accelerated technology development, which influences CCAM but also the methods and tools that can be used and developed. The late Impact RIAs will provide foundation for the CCAM SRIA update for the Partnership's final societal impact assessment from Cluster 1 results. (ex-post impact assessment).

The Workforce R&I action starting in the third year of the partnership builds the base for addressing the consequences of CCAM deployment on the workforce and educational value chains. A second action in the third phase, following an implementation period, will advance the basis for realising expectations on job growth through CCAM.

Cluster 6

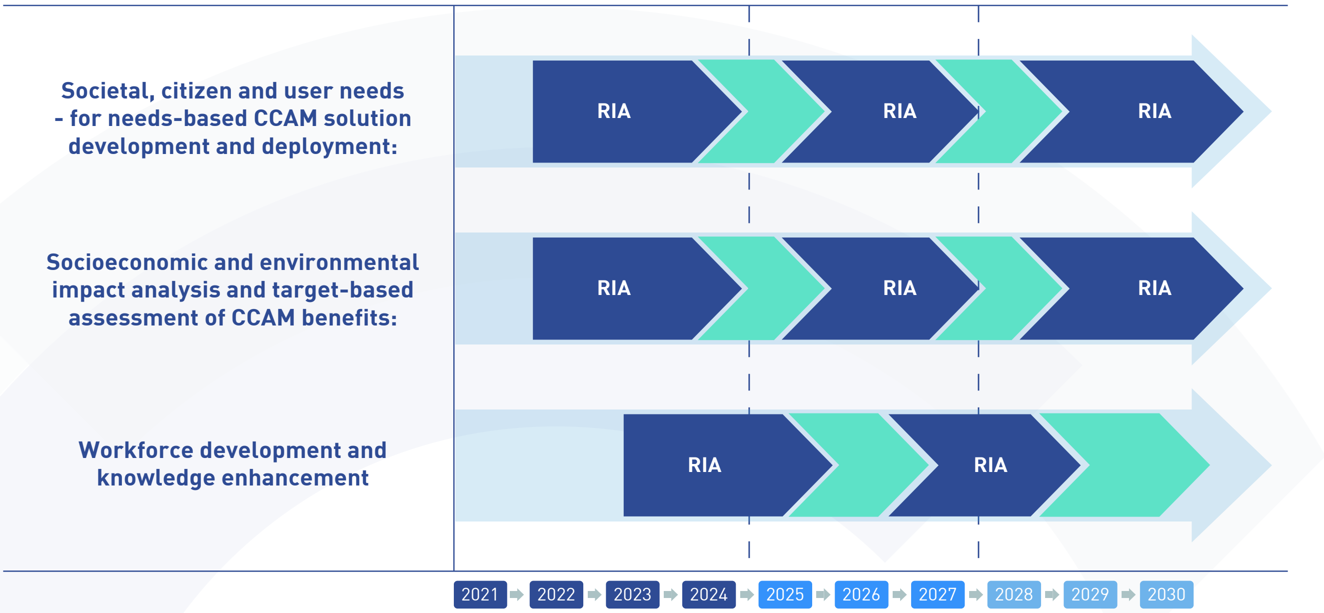
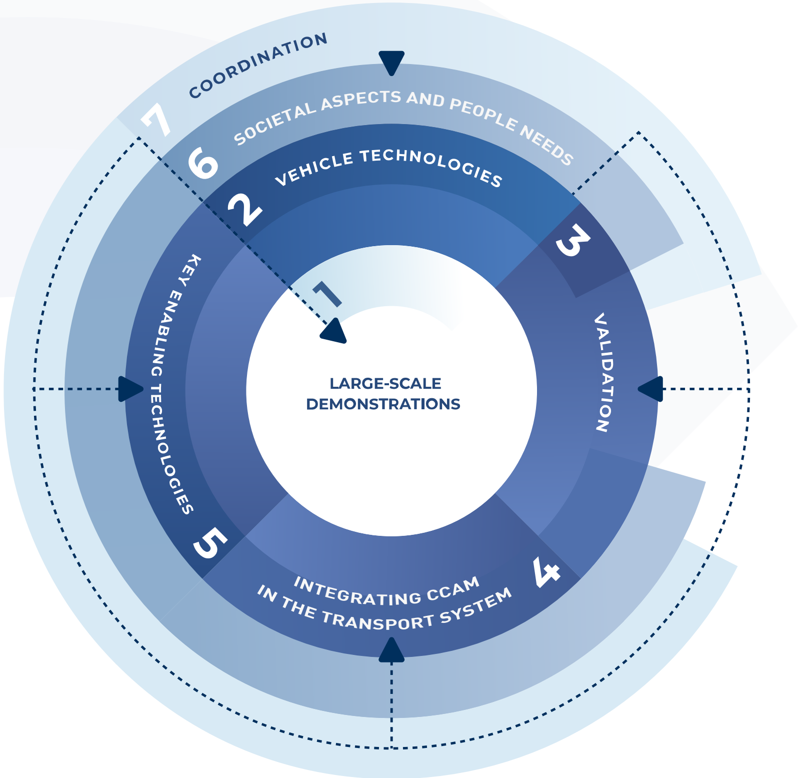


Figure 17: Cluster 6 R&I Actions over the Partnership Programme timeline.

9.7 Cluster 7: Coordination

Introduction

Coordination of R&I and testing activities across Europe is required to address the current fragmentation of R&I efforts and the lack of a coherent, longer-term vision and strategy as identified in PD3.



Harmonised approaches, common methodologies and tools to facilitate the exchange of best practices and lessons learned will support the collaboration across the complex cross-sectorial value chain needed for the organisation of Large-scale Demonstration and future scale-up to the impacts of complete CCAM solutions.

Cluster 7 will

- Provide the Common evaluation methodology to be applied in Large-scale Demonstrations, tests and pilots of EU and as much as possible national projects (to Clusters 1, 2, 3, 4 and 5).
- Provide a Common test data exchange infrastructure (data space) with features facilitating the development and validation of CCAM functions and services, and further develop and adapt a data exchange framework by sharing lessons learnt and best practices to Cluster 1, 2, 3, 4 and 5.
- Provide knowledge base and guidance on R&I needs, gaps and tools (to all Clusters)..
- Provide means of assessing the level of awareness and attitudes of European citizens (to Cluster 6) and decision makers
- Coordinate the CCAM Stakeholder forum and maintain stakeholder engagement tools (e.g. workshops) to consult for expectations and feedback for all Clusters.
- Facilitate dissemination of information among past and ongoing R&I and demonstration activities in order to ensure early awareness of plans, results and lessons learned to prevent silos, overlaps and redundancies
- Support the monitoring of the progress made on the targets and impacts set by the CCAM Partnerships regarding the use of harmonised methodologies and tools
- Support the work of the States Representative Group and stimulate cooperation between Member States

The necessity of cross-sector collaboration in Europe for the development, testing and deployment of Connected Automated Driving (CAD) has been highlighted in the Declaration of Amsterdam, the GEAR 2030 final report and the Communication from the European Commission "On the road to automated mobility". The objective of this cluster is to capitalise on shared knowledge and develop harmonised approaches and European frameworks for the assessment of impacts of CCAM technologies, systems and services, testing on public roads and sharing of Test data, building on the work carried out by EU-funded Coordination and Support Actions and by Working Group 2 of the CCAM Platform in 2019-2020. The cluster will also create a stakeholder forum to improve collaboration and extend stakeholder engagement beyond the Partnership members. It will also maintain and extend the EU-wide Knowledge Base that will publish and disseminate R&I and piloting activities and their results, as well as standards and methodologies enabling the exchange of knowledge, experiences and lessons learned. The different activities of the cluster will support the coordination and cooperation of R&I, testing activities and living labs across Europe, facilitating the collaboration between stakeholders from all sectors and create the fundaments to move from testing and piloting towards the harmonised deployment and operations of CCAM with consensus on how it supports the societal goals.

For the first two phases of the Partnership, the Knowledge Base and tools developed by Cluster 7 projects and coordination actions will enable the necessary exchange of experience, practices and methodologies to develop the key building blocks and set up large scale demonstrations. The EU Framework for testing on public roads is being progressively developed by the first Cluster 7 project FAME with the involvement of all CCAM projects funded under the Partnership so far. While the final version of the framework and associated common evaluation methodology will be available in 2025, intermediate versions and associated tools will be available from 2024. The availability of the EU Framework, marking the achievements of M1 and M2 will be a significant enabler to reach SO4 and GO4 by supporting alignment and complementarity of R&I in Europe, thus optimizing investments. For the last phase of the Partnership, these tools should also provide support for stakeholders to move into operations by identifying key building blocks and standards for deploying pilot services and enable capacity building for key actors of different use cases /applications domains.

The successful deployment of CCAM solutions largely relies on meeting the needs of citizens and users. It is essential to involve end-users in the process, through activities such as co-creation, and to consider societal needs right from the start of technology and service development. The Knowledge Base can assist in this effort by producing easily understandable content for non-experts, with additional approaches and formats, and collaborating with public authorities to increase awareness and comprehension of CCAM. For existing solutions, it should also provide information about limitations and related risks.

The European framework for testing on public roads consists of several components necessary for efficient legal approval processes, validation, data exchange and analysis.

- Help streamlining the different national and local processes for obtaining testing permissions; facilitate mutual recognition of procedures across Member States, ultimately resulting in unified testing approaches for a better data analysis, verification and validation of systems and services.
- A common evaluation methodology for large-scale demonstration pilots, including but not limited to user evaluation and socio-economic impact assessment will allow comparability of results, complementing evaluations and meta-analysis over multiple evaluation studies. Similarly, the effectiveness of large scale testing in Europe can be largely increased by a more systematic exchange of experience, test results, and test data.
- Once developed and available, the evaluation methodology will need to be implemented for existing and innovative use cases by CCAM projects and aligned with national mobility strategies and approaches. Training programmes for CCAM projects will be necessary to integrate the methodology and to collect feedback on lessons learned during its implementation.

Member States and Associated Countries to Horizon Europe will have an active role in this cluster and in the related R&I and Coordination and Support Actions. A strong link will be required with the States Representatives Group (SRG) of the Partnership as well as with the national/local clusters and ecosystem for the operational aspects, in particular regarding testing conditions and regulations and associated harmonisation aspects. The SRG will need support to collect and analyse information on national R&I initiatives and to implement cooperation activities.

Advancing the State of the Art

The initiatives of this cluster are building on a strong legacy of EU-funded projects as well as ongoing European, national and international harmonisation activities. The successive projects VRA[104], three FOT-Net Projects[105], CARTRE[106], SCOUT[107] and ARCADE [108] have federated large networks of stakeholders and driven consensus building across stakeholders on challenges, needs and requirements for CAD and Field Operational Tests. These actions allowed building harmonised views and contributed to the development of European R&I agendas. The online Knowledge Base initially developed by the ARCADE CSA and subsequently extended in the FAME [109] project gathers up-to-date information on CCAM-related R&I projects and pilot activities in Europe and beyond, regulations and policies, standards, and impact assessment and data sharing methodologies. FAME is developing knowledge summaries in order to deliver more targeted content to specific stakeholder categories like public authorities or cities. Other projects like WE-TRANSFORM [110] and SINFONICA [111] are developing Knowledge Bases focusing on societal aspects and impacts.

This is complementing the CORDIS and TRIMIS [112] online databases maintained by the European Commission, the latter aiming at supporting the development and monitoring of the Strategic Transport Research and Innovation Agenda [113] (STRIA). JRC regularly carries out a foresight and horizon scanning with a similar objective. Similarly, some Member States have set up knowledge sharing, testing monitoring or cooperation platforms (e.g. Finland with TransDigi[114], The Netherlands with the Knowledge Agenda Automated Driving, Germany with the "Testfeld monitoring" [115] tool). The STAPLES [116] project financed by CEDR [117] is looking into the test facilities across Europe but a wider scope of living labs on mobility (and a classification of them) is needed.

Several instruments and evaluation methodologies have been developed and are being used by EU-funded projects or international initiatives. These include the FESTA [118] Handbook, the Trilateral Impact Assessment Framework for Automation in Road Transportation (EU–US–Japan cooperation), the C-Roads Evaluation and Assessment Plan [119] the LEVITATE [120] Policy Support Tool (PST) as well as the methodologies of L3Pilot [121] and the follow-up project Hi-Drive, AUTOPILOT [122], AVENUE [123],

104 https://trimis.ec.europa.eu/project/support-action-vehicle-and-road-automation-network 106 https://wiki.fot-net.eu/index.php/FOT-Net

105 https://wiki.fot-net.eu/index.php/FOT-Net

106 https://trimis.ec.europa.eu/project/coordination-automated-road-transport-deployment-europe

107 https://trimis.ec.europa.eu/project/safe-and-connected-automation-road-transport

108 https://connectedautomateddriving.eu/about/arcade-project/

109 https://www.connectedautomateddriving.eu/about/fame/

110 https://cordis.europa.eu/project/id/101006900

111 https://cordis.europa.eu/project/id/101064988

112 Transport Research and Innovation Monitoring and Information System (https://trimis.ec.europa.eu/)

113 https://ec.europa.eu/research/transport/pdf/stria/stria-roadmap_on_connected_and_automated_transport2019-TRIMIS_website.pdf

114 http://www.transdigi.fi/en/transdigi

115 https://www.testfeldmonitor.de/Testfeldmonitoring/DE/Home/home_node.html

116 https://www.stapleproject.eu/about

117 Conference of European Directors of Roads (https://www.cedr.eu/)

118 https://wiki.fot-net.eu/index.php/FESTA_Handbook

119 https://www.c-roads.eu/platform/documents.html

120 https://levitate-project.eu/

121 https://l3pilot.eu/about/

122 https://autopilot-project.eu/

123 https://h2020-avenue.eu/

EU EIP[124], ENSEMBLE[125], MANTRA[126], SAM and SHOW[127] projects. Collaborations between some of these projects on harmonised methodologies have been carried out and different approaches have been collected by ARCADE and made available in the Knowledge base. The EU project SHOW and the French SAM project are preparing the frameworks for data collection and evaluation methodologies of multiple-FOT projects, gathering various Use Cases, vehicles, systems and services.

FAME is developing a common evaluation methodology (CEM) building on the knowledge gathered from these initiatives, The CEM will provides guidance on how to set up and carry out an evaluation or assessment of direct and indirect impacts of CCAM solutions. It will be a part of European framework for testing on public roads that should be used by all projects from the CCAM Partnership carrying out evaluations.

Similarly, initiatives in Europe have defined common formats or have set up data catalogues to facilitate the exchange of test data, e.g. L3Pilot Common Data Format, FOT-Net Wiki, Catalogues and Data Sharing Framework. Common data formats for CCAM are also being specified by standardisation bodies like ASAM, ISO TC204 & CEN TC278.

The 4th High Level Meeting on CAD[128] organised by the Finnish Ministry of Transport in October 2020, highlighted the need to develop means towards mutual recognition of testing authorisations to facilitate experimental testing. Some initiatives have been collecting information about testing regulations across Members States in Europe, collecting best practices or developing guidelines and recommendations to facilitate the organisation of cross-border testing. The CCAM Knowledge base has gathered content on Regulation & Policies with a focus on testing exemption procedures. ENSEMBLE started discussions on the requirements for mutual recognition of exemption procedures for platooning. Preparatory work is also being carried out on a framework for mutual recognition of exemption authorizations as part of the DE-FR-LU cross-border testbed. Working Group 4, on Safety Validation, of the CCAM platform set up by the European Commission has worked on "Guidelines for testing of automated and connected vehicles" and preparing recommendations for mutual recognition. The FAME project is working with the SRG on an analysis of CCAM testing procedures and administrative frameworks as well as of testing initiatives (on public roads) and CCAM use cases including legal, administrative, technical and ethical aspects per member state. L3Pilot has developed a Code of Practice and the SHOW project is looking into the issues and solutions for cross European test permits.

The EU project HEADSTART[129] and German project VV Methods[130], which have continued the work of the German project PEGASUS[131], are looking into harmonised safety validation approaches. The EU funded SUNRISE[132] project is building on the results from HEADSTART to develop a Safety Assurance Framework. An international collaboration is ongoing between SUNRISE, VV-Methods and the Japanese SAKURA[133] project which develops scenario-based safety assurance methodologies and a scenario database. Euro NCAP has defined a roadmap for definition and introduction of CAD safety assessment protocols.

124 https://www.its-platform.eu/

125 https://platooningensemble.eu/

126 https://www.mantra-research.eu/

127 https://show-project.eu/

128 https://www.lvm.fi/en/-/high-level-meeting-on-connected-and-automated-driving-aims-at-strengthening-cooperation-1234725

129 https://www.headstart-project.eu/

130 https://www.ika.rwth-aachen.de/en/research/projects/automated-driving/3120-vv-methods.html

131 https://www.pegasusprojekt.de/en/

132 https://ccam-sunrise-project.eu/

133 https://www.sakura-prj.go.jp/project_info/

Beyond Europe, initiatives have been launched to gather data about testing activities to evaluate the readiness of AVs for public use, increase transparency and raise public awareness. The AV TEST Initiative from US DOT (NHTSA) provides an online platform for sharing automated driving system on-road testing activities and other pertinent information with the public. Similarly, the Autonomous Vehicle Monitoring and Evaluation System (OLIVE) from Singapore's Land Transport Authority gathers data from Automated Vehicles and CCTV systems for evaluation purposes.

R&I Actions and expected outcome

The specific R&I actions relating to "Coordination" are the following:

- **EU-wide knowledge base and stakeholder forum on CCAM**

  Continue and extend the existing EU-wide Knowledge Base[134] on CCAM as the "one-stop shop" for the exchange of knowledge and experiences on CCAM in Europe and beyond and to promote existing and valuable datasets. In a second phase, expand the Knowledge Base to support the CCAM stakeholder community and CCAM Partnership for moving into operations (minimal building blocks requirements, standards and common definitions to run pilot services across Europe). Identify further needs for targeted content for specific stakeholder categories and in particular, develop content that is accessible to non-experts, thereby supporting capacity building of the general public. To support the organisation of large scale demonstration in the last phase of the Partnership, the Knowledge Base should in particular become an Experience Base. The action should also establish a network of experts and provide a forum to facilitate their interaction.

- **Common Evaluation Methodology**

  Establish a well-structured overview of European evaluation methodologies for impact assessment and their testing instances (test sites, living labs, simulations, open road) and develop a common evaluation framework and methodology (EU-CEM) with common indicators for large- scale demonstration pilots and a taxonomy tool to ensure that everyone speaks the same language. Align the methodology with national strategies by evaluating and updating it through targeted discussions with Member States/Associated countries. The practical implementation of the EU-CEM (for existing and innovative use cases) will need to be supported by providing training programmes for CCAM projects to integrate the methodology.

- **Test Data Exchange Infrastructure and Framework**

  Develop and adapt a test data exchange infrastructure and framework. The infrastructure shall facilitate data exchange and use of principles in the European data strategy. The framework shall address legal and administrative as well as technical aspects such as data provision, access, protection of user data, and labelling of data and proper description of the data.

- **Harmonized legal frameworks and approval processes for CCAM testing on public road**

  Establish harmonized legal frameworks and approval processes for CCAM testing on public road based on criteria for mutual recognition of procedures to facilitate the development of both cross-border testing and support authorities, and in particular cities, in organising piloting projects. Facilitate the work of the CCAM SRG and stimulate the cooperation between EU Member States/ Associated Countries for improved coordination of activities in the areas identified as priorities by the SRG. Provide an analysis of initiatives in EU Member States/Associated countries and support the SRG in identifying areas for R&I cooperation and how to get to deployment.

134 The existing Knowledge Base (https://knowledge-base.connectedautomateddriving.eu) has been established as the one-stop shop for CCAM knowledge in Europe, which is used by an increasing number of stakeholders from Europe and other regions of the world. It features a number of essential elements for the identification of future R&I needs, supporting the harmonisation of procedures and the transferability of best practices. These elements include past and present R&I projects (both on a European and national level), information on related regulation and national policies, strategies and action plans, guidelines and evaluation methodologies, data sharing, relevant terms, related events (including materials from past events).

On the basis of all the above R&I actions, the expected outcomes include:

- Comprehensive analysis of all demonstrated CCAM Use Cases and agreed strategy and harmonised approaches for implementing future large-scale demonstrations in Europe.
- Common framework for large-scale demonstration pilots in Europe including the identification of common Use Cases and Operational Design Domains (ODDs) as well as the definition of a common taxonomy and tools for scenario assessment.
- Common evaluation methodology which will allow comparability of results, complementing evaluations and meta-analysis over multiple evaluation studies (building on the outcome and recommendations from working group 2 of the CCAM Platform.
- Test data exchange infrastructure and framework including best practices and guidelines, common data formats, a common openly accessible data exchange infrastructure safeguarding ethical usage of test data in a trusted and transparent manner to improve cooperation across projects and stakeholders. A reference platform should constitute an intermediary step towards future common data spaces that CCAM products and services must be part of or interact with.
- Develop protocols and governance models for a unified European shared and publicly available database on incidents and other events related to safety of automated vehicles.
- Harmonised conditions and processes for tests of CCAM systems on public roads, including criteria for a mutual recognition of procedures (building on the outcome and recommendations from working group 4 of the CCAM Platform).
- Common basis for CCAM Knowledge in the EU through an up-to-date and continuously maintained Knowledge Base on CCAM[135] adapted to the needs of the potential members of the European Partnership on CCAM and all relevant stakeholders.
- Efficient and sustainable governance structure for the collection of CCAM Knowledge in Europe and globally, thus facilitating the engagement and contribution of stakeholders from all sectors and in particular exchanges and cooperation with and amongst Member States.
- Network of experts in the different thematic fields of R&I on CCAM with adequate tools and processes to enable the exchange of experiences and practices, stimulate collaboration and cooperation between all CCAM stakeholders and reach consensus on challenges and future R&I needs.

Timeline

Cluster 7 coordinates and supports the partnership and all planned R&I actions of this cluster start early on. The actions advance during the CCAM Partnership timeline to support testing, implementation and evaluation in Cluster 1. Expected outcomes of the first actions will allow for the use of common and harmonised methodologies and lessons learned by projects and testing activities after the first phase of the CCAM Partnership. Coordination and Support Actions will follow to continuously maintain and update the knowledge base and methodologies after the first phase, supporting and collaborating with actions from all Clusters and ensuring harmonised and coordinated approaches that are updated with experience and lessons learned. Once the CEM is developed in the first RIA, a follow-up CSA is needed to reflect the feedback of the first project, try it out in practice and align it with national strategies. The idea is to keep the CEM as a living document like the FESTA Handbook which has been regularly updated to reflect the latest lessons learned and good practices. Similarly, the data sharing landscape will evolve over time and an IA should follow upon the initial RIA to ensure that the infrastructure remains adapted to the developments in CCAM and features of data spaces. The data environment is constantly updated and will be different than today in 4-5 years. A RIA would be necessary afterwards to keep up with the ever changing landscape.

The following image aims at making this progression process transparent.

135 https://knowledge-base.connectedautomateddriving.eu/

Cluster 7

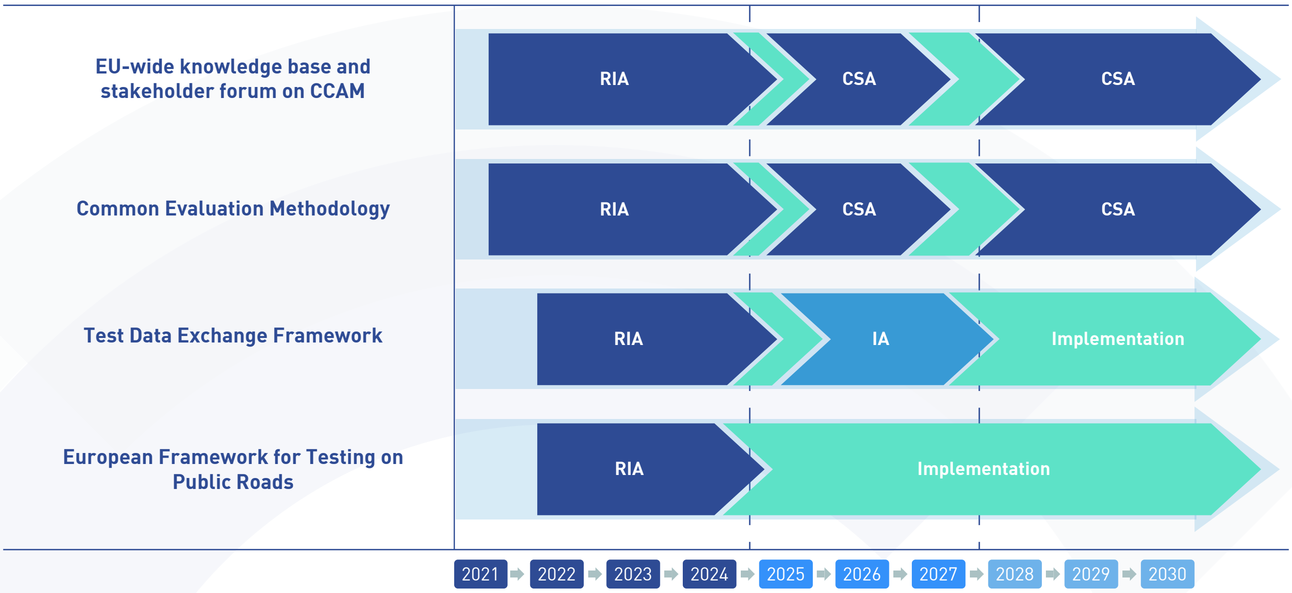


Figure 18: Cluster 7 R&I Actions over the Partnership Programme timeline.

10. SRIA Implementation

The Partnership will be implemented through collaborative R&I projects funded by the Horizon Europe programme and by additional activities provided in kind by the partners. A number of activities, such as coordination and dissemination efforts, support to harmonisation and standardisation, international cooperation, etc. will be covered both by EU funding in the different types of EU projects and complemented by in-kind additional activities.

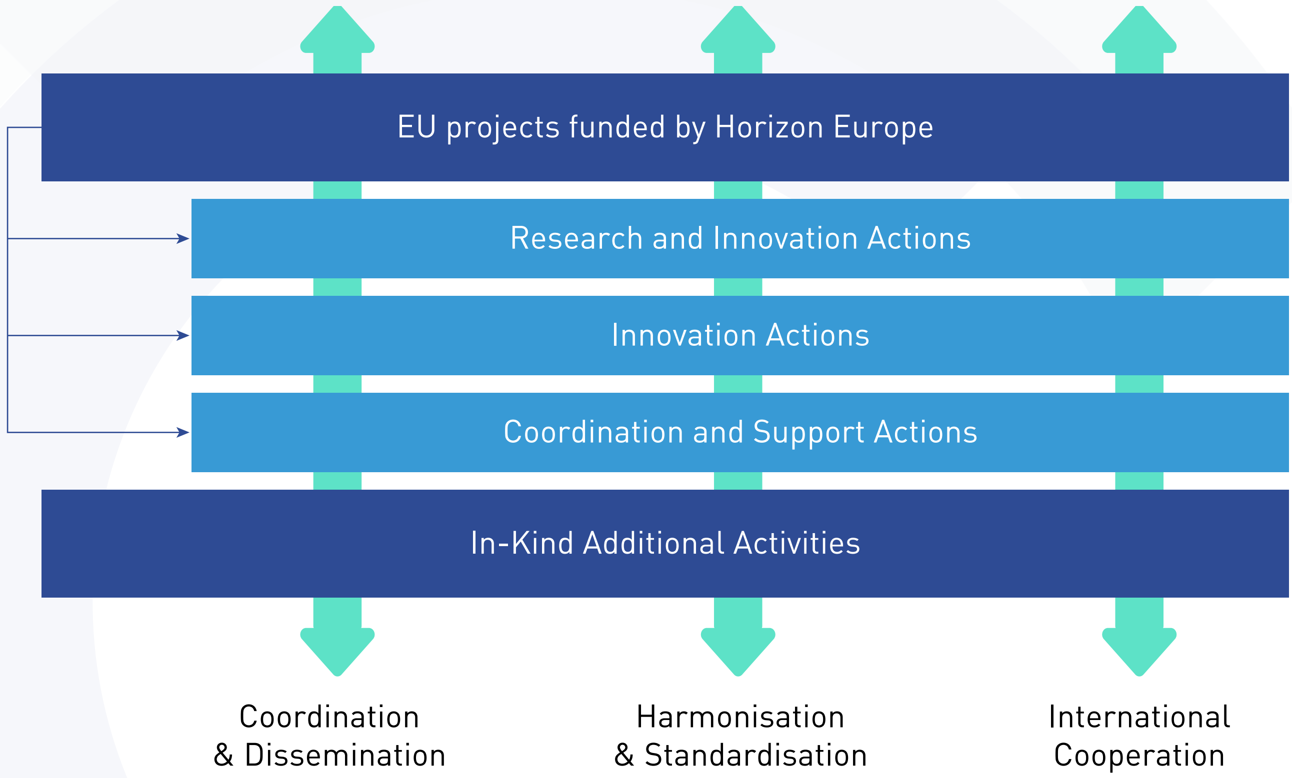


Figure 19: SRIA Implementation activities

10.1. CCAM calls for projects under Horizon Europe

The SRIA describes the R&I Actions necessary to advance toward the Deployment Readiness of CCAM. An increasing maturity of technologies (TRL) and successful delivery of enabling activities will be needed. The implementation of the SRIA will mostly be done through the different types of European collaborative projects that are described in the following sections. The members of the CCAM Partnership have expressed their willingness to contribute to these activities.

Research and Innovation Actions

Research and Innovation Actions (aiming at TRL: 3-5 [136].) are the basis for all developments towards cooperative, connected and automated mobility. The Research and Innovation actions developed in the seven CCAM Clusters will be aiming at delivering new knowledge, and/or be exploring the feasibility of improved or new technologies. Instruments of Research and Innovation Actions can include e.g. desk research, feasibility studies, technology development, HMI studies including user tests, laboratory testing, model development, cost-benefit analysis, risk assessment and simulations. Some examples of topics for RIAs expected:

136 Section G on TRL definitions: https://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-ga_en.pdf

- The development of reliable occupant protection technologies and HMI solutions to ensure the safety of highly automated vehicles. This will require a mix of research activities including
- modelling and simulation in addition to testing solutions in the laboratory in order to provide significant advances with respect to the state-of-the-art.
- The development of explainable and trustworthy Artificial Intelligence (AI) concepts, techniques and models for CCAM, including the development of decision making (i.e. planning and acting) based on robust and reliable detection and perception, as well as unbiased AI training approaches.
- The development of technologies for cyber secure and resilient CCAM for safe and secure operation. This will require development and validation of methods and tools, as well as specific security building blocks, with a systems approach and harmonised interfaces and protocols to enable integration of vehicles, infrastructure, back-offices and mobility service centres
- The development of methodology and indicators to assess the impacts of CCAM solutions on mobility and wider socio-economic effects. This requires a multidisciplinary approach encompassing aspects such as public health, land use/infrastructure need, environmental aspects such as energy use, accessibility, air quality, carbon emissions and impact on economy, employment, working conditions and required skills etc.

Innovation Actions

On the basis of the results of amongst others the Research and Innovation Actions, further development shall be carried out in the Innovation Actions (aiming at TRL: 6-8). The Innovation Actions will be developing e.g. designs for new, altered or improved products and/or services. Activities may include prototyping, testing, demonstrating, piloting, large-scale technology and application validation including validation of the economic viability. Two examples of topics for RIAs expected:

- The development of more powerful and reliable on-board perception and decision-making technologies – activities need to include also the testing of prototype solutions on vehicles in realistic conditions in order to ensure that complex environmental conditions can be tackled accordingly.
- The central element of the CCAM Partnership is the large-scale demonstration activities (see Chapter 7) in Cluster 1. While demonstrations with Pilots and FOTs focus on the technical usability, living labs will be a key instrument to evaluate the usability of CCAM within society by including citizens in testing and demonstration.

Coordination and Support Actions

Coordination and Support Actions will be required beyond Research and Innovation Actions or innovation Actions to pave the way towards deployment in cases where building of consensus is required among stakeholders for harmonised approaches and to ensure that common methodologies are promoted and regularly updated to reflect lessons learned and best practices. Coordination and Support Actions have been defined in the Horizon 2020 Framework programme[137] as "Actions consisting primarily of accompanying measures such as standardisation, dissemination, awareness- raising and communication, networking, coordination or support services, policy dialogues and mutual learning exercises and studies, including design studies for new infrastructure and may also include complementary activities of strategic planning, networking and coordination between programmes in different countries".

137 HORIZON2020–WORKPROGRAMME2018-2020GeneralAnnexes,https://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018- 2020/annexes/h2020-wp1820-annex-d-csa_en.pdf

In the case of CCAM, CSAs are in particular expected to

- Support the development of harmonised methodologies and framework for testing, evaluation and piloting of CCAM solutions and services
- Support reaching consensus among stakeholders on challenges and solutions related to the development and deployment of CCAM solutions and services
- Contribute to raising awareness about CCAM solutions and foster the exchanges of best practices and lessons learned.
- Organise contributions to policy dialogues and support the definition of policy and R&I agendas.

The following activities will be cross-cutting, covered by the different types of EU projects described in 8.1, and complemented by in-kind additional activities listed in 8.2.

Coordination & Dissemination

The Partnership will undertake coordination activities in order to facilitate networking and contribute to the building of the stakeholders community: it will facilitate new and improved connections between the various actors, including academic, industry, civil society and policy. Also the local level need to be involved e.g. users representatives, local authorities, providers of local mobility services, etc. This community building between researchers and stakeholders should help to exploit the results from research: raising awareness for technological development and innovation activities, encouraging the uptake of new solutions into new services, and leveraging the policy objectives impact. Cluster 7 will be in the lead here, following up the results already established in projects like ARCADE[138]. All Partnership members will be invited to contribute to these activities developed by the cluster 7 projects.

Regarding dissemination, the ambition is to spread the information, results and impacts delivered by the Partnership activities among the stakeholders. The dissemination and communication should also support the long-term ambitions of the Partnership to include a large variety of stakeholders, including start-ups and SMEs. The large-scale demonstrations especially in living labs provide opportunities to involve the civil society and enhance public awareness, which will be also studied and promoted through the activities of the cluster 6. The dissemination and communication strategy should include information sharing through website and newsletters, knowledge sharing among partners, coordinated outreach activities and jointly organised conferences and events together with the European institutions and various stakeholders including civil society representatives.

Harmonisation & Standardisation

To ensure that technologies and methods developed within CCAM can be rolled out in Europe and to avoid cross-border and cross-supplier conflicts, the Partnership will contribute to the harmonisation of CCAM enabled mobility solutions and development of technical standards from the very beginning. The members of the Partnership Association will cooperate with European standardisation bodies addressing interoperability of new technologies for cooperative, connected and automated mobility, which will also lay a foundation for involvement with international standardisation organisations further enhancing European competitiveness. Concretely, the Partnership projects will be required to include this objective of promoting standardisation in their activities where relevant. They should plan upfront the dissemination of their results towards the standardisation bodies, providing support from their research results to the standardisation processes.

138 ARCADEGrantagreementID:824251

The Partnership Association itself will support this process by disseminating and promoting the projects activities and results, e.g. through targeted events with the involved stakeholders. It will however not act itself within standardisation bodies.

International Cooperation

International collaboration is essential for research and innovation in CCAM because it allows researchers and innovators to share knowledge and resources, develop harmonised solutions that work across borders, address common challenges and opportunities at speed, and to reduce costs and risks along global value chains. At the same time, there are also some limitations and potential risks, including intellectual property theft, dominance in standardization activities, uneven distribution of economic benefits of newly generated knowledge on CCAM among partners, differences in regulatory frameworks hindering common CCAM solutions, and cultural differences implying inconsistencies in ethics standards. While the benefits of international collaboration certainly prevail within the European Research Area, it is important for the CCAM partnership to carefully weigh up opportunities against threats in line with the paradigm of strategic autonomy of Horizon Europe when capturing, envisioning and implementing international research and innovation projects beyond the EU. On the other hand, the analysis of successful implementations of particular CCAM services or uses cases in certain regions in the light of the different policy or regulatory contexts can provide interesting insight on necessary conditions for efficient deployment and may lead to better coordinated policies.

For the collaboration beyond Europe, the Trilateral Working Group on Automated Road Transport by the EU, United States of America and Japan plays a key role in enabling exchange of information on strategic orientations and allowing to identify complementarities between topics of research and innovation on CCAM. The Sub-Working Groups on Impact Assessment, Human Factors and Roadworthiness Testing have been effective in the development of harmonised approaches and the exchange of best practices so far. In view of the ambivalence of global collaboration, this work is complemented by an analysis of objectives, programmes and projects of road transport research including CCAM in the U.S., Japan, China and South Korea in the context of the EU-funded Coordination and Support Action Future Horizon. Building on such positive experiences and, following up on the overview of the CCAM policy and R&I landscape prepared by the ARCADE project for Australia, Canada, Israel, South Korea, Singapore and UAE, the FAME project will define concrete cooperation areas and identify counterparts and opportunities for (collaboration with the different regions so to further enable a structuring of international dialogue with strategic partners according to the R&I areas of the CCAM Clusters, and possibly also feeding into future Horizon Europe Work Programme requirements).

First results of the analyses indicate potential benefits of collaborations on topics and with countries as follows:

- environment perception and software-defined vehicle platforms with the U.S.,
- role of CCAM for societal transformation with Japan,
- safety of CCAM and the Intelligent Connected Vehicle[139] (ICV) development path with China,
- remote control in challenging traffic situations with South Korea,
- safety related vehicle data and impact assessment methodologies with Australia,
- infrastructure and smart traffic management with Dubai.

At the same time, the analysis warns of standardization for CCAM that might affect European values and ethics, and it points out the threat of a market dominance by IT platform companies, and new

139 About CICV Intelligent and Connected Vehicles (Beijing) Research Institute Co.,Ltd.: http://www.china-icv.cn/en/about

entrants into the CCAM value chain, e.g. from robotics. Beyond that, certain research and innovation issues related to CCAM require global cooperation by definition, for example, the question whether the intelligence of CCAM should be located in each single vehicle or in the cloud, or how earth orbit satellites may be used to support CCAM, e.g. by teleoperation, or on the role of physical and digital infrastructure. Moreover, a global collection, comparison and assessment of state of the art, best practices and open questions should be aimed at.

In addition to the CCAM Knowledge Base, the stakeholder engagement tools from Cluster 7, including the EUCAD conferences, co-organised by the partnership, as well as similar international events in other regions like the ARTS conference in US or the SIP-adus (now Mobility Innovation Week) workshops in Japan, provide important platforms for the exchange of knowledge and identification of cooperation opportunities.

10.2 In-Kind Additional Activities

In addition to the actions funded by the Horizon Europe programme, a number of in-kind Additional Activities will be done by the Partnership in order to support its objectives. These contributions demonstrate the commitment of the partners to work together towards the common objectives, and they are an added value of setting such a European Partnership. The Memorandum of Understanding of CCAM provides the list of in-kind additional activities that may be covered by the members:

- **i.** Coordination and development of projects, dissemination of results and achievements of the partnership, including identification of success stories. Support to knowledge building and sharing by contributing to a joint database.
- **ii.** Activities to involve and raise awareness of users and communities at national, regional and local levels. Specific dissemination of Partnership results towards decision-makers.
- **iii.** Support to relevant standardisation, certification and regulatory activities.
- **iv.** Organisation and participation in conferences, expert webinars on specific topics, and stakeholders networking events.
- **v.** Support R&I strategy alignment and synergies by building common roadmaps.
- **vi.** Actions to develop synergies with other European, transnational and national R&I initiatives. Including coordination with other related partnerships at EU level.
- **vii.** Complementary projects at national, regional, local and private level: projects covering lower or higher TRL activities in the field of the partnership, or projects occurring in parallel to the partnership activities e.g. other trials and field tests.
- **viii.** Education, training and skills development: employees benefiting from upskilling and training schemes. Adaptation of academic schemes.

The definition, planning and reporting of these in-kind additional activities will be organised by the Partnership Board as part of the work process described in chapter 9, in consultation with the stakeholders.

10.3 Commitments and contributions of partners

The ambition of the Partnership is to make Europe a world leader in the deployment of connected and automated mobility, and making a step-change in Europe in bringing down the number of road fatalities as well as reducing harmful emissions from transport and reducing congestion.These very ambitious objectives will not be reached by the research and innovation actions alone, and this is why the Additional Activities are of high importance, and the involvement of as many stakeholders as possible is key.

After developing, testing and successfully demonstrating mobility services based on automated driving technologies and cooperative systems, the production and market penetration is the actual key to realise the expected impacts. The technological evolution must meet market needs and customers' expectations to leverage the great opportunities for the industry in terms of mass manufacturing as well as new business models or new mobility services provided by CCAM.

This requires a scale up phase, with investments in the range of 5 to 10 times the scale of the overall Partnership budget. These comprise technology development in high TRL levels (8-9) and the deployment of technologies, systems and services, ramping up manufacturing capabilities and pilot lines, infrastructure investments, and investments in new jobs and skills required. The Partnership will foster the collaboration of stakeholders to support this process, by encouraging synergies and the mobilisation of additional investments, for example in regard to further testing:

- OEMs and suppliers will contribute with their fleets of test vehicles and equipment.
- Research sector contributes with know-how, innovation and assessment capabilities.
- Cities, regions and infrastructure operators provide the foundation for living lab environments to implement large scale testing and demos and the link to users and citizens.
- Public transport providers use their fleet and operations to test CCAM services.
- Mobile network operators will address (5G) connectivity needs to enable seamless mobility services.
- Transport industry supports CCAM with their expertise in heterogeneous and complex system landscapes.
- Cross-sector collaboration leading to joint investments is also very important for the entire lifecycle of CCAM elements (roads, services and vehicles) from early stages of research up to deployment and maintenance over the entire life cycle of the assets placed to the market.
- All actors necessary for the deployment need to be involved already in the first phases, together with cross-sector research and innovation partners, in order to contribute jointly to develop CCAM on the Technology Readiness Levels (TRL) up to some pre-deployment (Horizon Europe scope).
- When industry is entering competitive phase, i.e. development towards market, collaboration with infrastructure actors is needed for preparing coherent and harmonised deployment. Since different investment planning cycles represent a significant challenge (e.g. sufficient lead time for planning deployment budgets), there are strong merits of better cycle synchronisation identified earlier through the partnership in order to deliver value for all partners also at intermediate steps (aligned releases, updates, etc.).
- Deploying and/or adapting physical, digital and operational infrastructure in support of CCAM is costly and the return on investment is to a significant extent contributing to societal goals (safety, traffic efficiency, decarbonisation). Hence, deploying CCAM needs support from infrastructure deployment focused co-funding programmes like the Connecting Europe

Facility (CEF 2) at the European level, or else will rely very much on investments by national programmes.

Following the setup of the Co-Programmed Partnership instrument in Horizon Europe, the contributions provided by the partnership members will be:

a. In-kind contributions to the projects funded by the EU (on the basis of non-reimbursed eligible costs);

b. In-kind contribution to the Additional Activities: these in-kind additional activities are those activities which contribute to achieving the objectives of the Partnership, including R&I at higher TRL and/or to ensure demonstration, market, regulatory and societal uptake, which are in the scope of the SRIA but are not covered by Union funding. These in-kind Additional Activities are defined by the Memorandum of Understanding and listed in chapter 8.2.

Contributions to a. will be quantified through the standard EU projects reporting procedure. Contributions to b. will be assessed through a harmonised reporting methodology.

In addition, the members of the Partnership will contribute to its leverage when making investments in operational activities: investments going beyond the work foreseen in the SRIA but contributing to achieve the objectives of the Partnership. These investments in operational activities will not be included in the calculation of the contributions provided by the Partners but will count as leverage of the Partnership. Depending on the stakeholders, these investments could take very various forms. The Memorandum of Understanding of CCAM provides the list that may be covered by the members:

i. Investments in infrastructures to support testing and deployment.

ii. Investments in start-ups or spin-offs.

iii. Investments in development to prepare market introduction.

iv. Investments in production capacity.

v. Training programmes for workforce.

These investments by both private and public stakeholders are expected to trigger a leverage effect of at least 5 times the initial EU funding and hence maximise the impact of the Partnership. It is however expected that most of these investments will come rather towards the end of the partnership lifetime and beyond its timeframe.

10.4 States Representatives Group

The CCAM Partnership Board has agreed on its first meeting (July 2021) to set up a States Representatives Group (SRG). The States Representatives Group should advise and actively support the achievement of objectives of the Co-programmed European Partnership and ensure complementarity with national policies, priorities and programmes. It consists of delegates from the EU Member States and the Associated Countries to Horizon Europe. They may review information and provide opinions on the progress of the Co-programmed European Partnership towards its scientific, economic and/or societal impacts. The Memorandum of Understanding (MoU)[140] for the CCAM Partnership lists several items which are also reflected in the Terms of Reference (ToR) for the States Representatives Group.

Meetings of the States Representatives Group are called two times a year and are also closely following the process of the High Level Meeting for Connected Automated Driving, linking back to the Amsterdam Declaration on cooperation in the field of Connected and Automated Driving (2016). Since the establishment of the States Representatives Group, the EU Presidency has always hosted the meetings (FR, CZ (2022), SE, SP (2023)…). Importance of dialogue between the States Representatives Group and the Partnership is highlighted by regularity of meetings and involvement of majority of EU Member States. A report on the meeting results is provided to the Transport, Telecommunications and

140 https://www.ccam.eu/wp-content/uploads/2021/11/FINAL_MoU_CCAM.pdf

Energy Council[141].

Processes have been established to increase the synergies between R&I programmes and related R&I policies on national and European level so that knowledge building, learning effects and buy in can be supported on a far broader basis than previously. This comprises a strategic view on CCAM as well as a more comprehensive overview of results patterns and lessons learned from national and European projects and their implementation. The single EU-wide CCAM platform set up by the European Commission between 2018 and 2021, through in particular its Working Group 2, has actively engaged Member States in the identification of needs for the coordination and cooperation of R&I activities. It also facilitated the sharing of information about national and regional testing and demonstration activities which have been of great support for the development of the Knowledge Base (https://www.connectedautomateddriving.eu/) set up by the ARCADE project. The SRG enables the continuity of the necessary exchange of R&I activities, best practices and lessons learned between Member States and Partnership. Addressing the research coordination needs (see Cluster 7), the FAME project provides support by a set of multiplier instruments which are key in achieving these goals: the Knowledge Base as one-stop-shop for CCAM related information and results, the EUCAD Conference and Symposium as the primary European forum for exchange as well as targeted events aiming at community knowledge building in special and/or expert domains.

The SRG is also extremely well positioned to identify the most relevant fields which are crucial for enabling both Partnership outcome to be implemented and the whole ecosystem for CCAM to be developed. The SRG facilitates discussion on possible regulatory actions which can amplify CCAM benefits and to trigger those actions via the HLM process. The focus on harmonisation of regulations for CCAM testing, physical and digital infrastructure for CCAM or data and connectivity has the potential to significantly contribute to common goals in CCAM testing and deployment. Activities and efforts in these areas pivotal for further progress of CCAM will be advanced by the SRG in a long-term perspective.

The States Representatives Group should advise and actively support the achievement of objectives of the Co-programmed European Partnership and ensure complementarity with national policies, priorities and programmes. They may review information and provide opinions on the progress of the Co-programmed European Partnership towards its scientific, economic and/or societal impacts.

The States Representatives Group may provide information to, and act as an interface with the Co-programmed European Partnership on the following matters:

a) The status of activities performed under national or regional policies, priorities and research and innovation programmes which are relevant to the Co-programmed European Partnership and identification of potential areas of cooperation, including concrete actions taken or envisaged for the deployment of relevant technologies and innovative solutions at the national or regional level;
b) Specific measures taken at national level or regional level to maximise the impacts of the results achieved, in particular dissemination events, dedicated technical workshops and communication activities;

c) Specific measures taken at national or regional level to support the exploitation, deployment and/or scale-up of the results achieved within the Co-programmed European Partnership;

d) Content and dissemination of training programmes for CCAM workforce, curricula and modules

10.5 Alignment, exchanges and joint actions with other Horizon Europe Partnerships and EU programmes

Strengthening coherence in research, technological development and innovation in Europe is a major objective when addressing the Problem Driver 3: Current R&I efforts are fragmented and

141 ExampleTTECouncil05.12.2022:https://data.consilium.europa.eu/doc/document/ST-15488-2022-INIT/en/pdf

lack a coherent, longer-term vision and strategy for targeting systemic solutions. Public and private stakeholders can develop synergetic effects for their investment plans to advance on vehicle and infrastructure technologies.

The CCAM Partnership focuses on cooperation with other complementary Partnerships/programmes:

- Towards zero emission road transport (2ZERO),
- Driving Urban Transitions (DUT),
- Transforming Europe's rail system
- Clean Aviation
- Integrated air traffic management
- CIVITAS

or Partnerships addressing enabling technologies for CCAM:

- Key Digital Technologies (KDT)
- Smart Networks and Services (SNS)
- Photonics
- AI, Data and Robotics
- Made in Europe
- European Union Agency for Cybersecurity.

This coordination will be facilitated through e.g.:

- alignment groups or institutional meetings,
- joint expert workshops,
- joint conference sessions.

The CCAM partnership furthermore aims to support the objectives of the Mission on "Climate-neutral and Smart Cities" by implementing large-scale demonstrations of automated mobility systems and services within cities.

Synergetic effects in the long-term could facilitate and accelerate deployment thanks to links with other European programmes and funding instruments (e.g. Connecting Europe Facility 2 – CEF 2, Important Projects of common European Interest – IPCEI, European Investment Bank - EIB, Recovery and Resilience Facility - RRF).

In the following paragraphs the coordination opportunities with other relevant European Partnerships and programmes is described. At the end of this chapter, a table shows involvement of the CCAM Clusters in cooperation with different Partnerships/programmes.

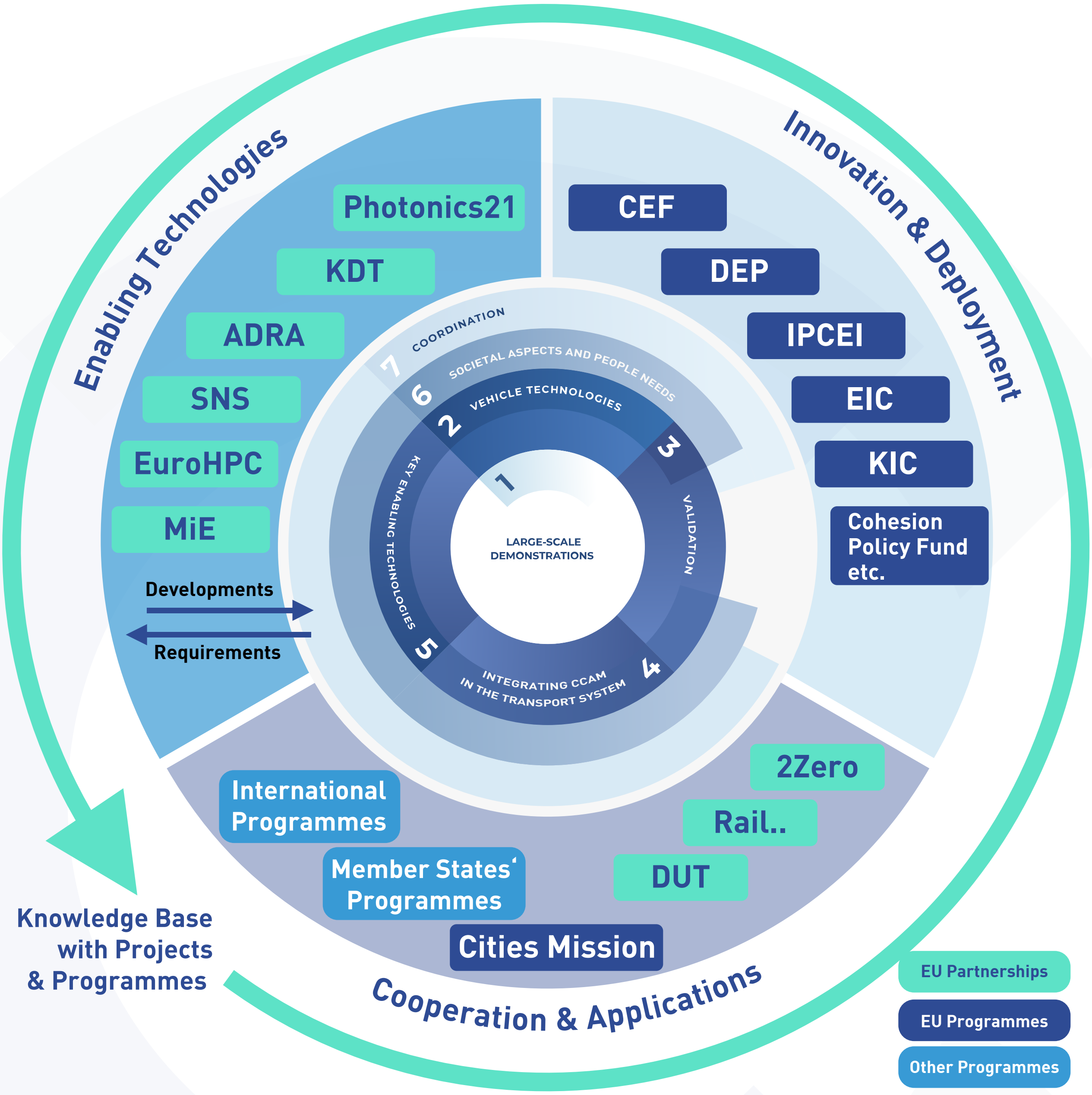


Figure 20: Interfaces between CCAM partnership and other European partnerships and synergetic effects with EU Programmes/Funds supporting deployment.

Cooperation between the CCAM Partnership and the 2ZERO Partnership

2Zero - Towards zero emission road transport - is a Co-Programmed Partnership in Horizon Europe. It is the follow-up of the EGVI - European Green Vehicles Initiative - Public-Private Partnership implemented in Horizon 2020. Its core objective is the acceleration of the introduction of zero emission vehicles in a system approach. The purpose of linking 2Zero with the CCAM Partnership is to seek the integration of the twin green and digital challenges, opening additional opportunities to improve the efficiency, both at vehicle level and at mobility system level. From this perspective, 2Zero and CCAM partnerships are core building blocks of the innovative climate neutral road transport mobility system.

In the Work Programme 2023 of the Cities Mission, there is a joint call with CCAM and 2Zero "Co-designed smart systems and services for user centred shared zero-emission mobility of people and goods in urban areas" has been successfully implemented.

In the Work Programme 2023 of the KDT Joint Undertaking, there is a coordinated call with CCAM and 2Zero on the Software Defined Vehicle, see Cooperation with KDT for details.

Further potential fields for cooperation

Striving for large scale demonstrations, there will be further potential fields of cooperation like identifying combined infrastructure needs of charging infrastructure with traffic management to improve combined traffic and charging efficiency and rollout, e.g. for trucks on highways as well as new and innovative concepts, solutions and services for zero-emission mobility, facilitated by CCAM and 2Zero innovations.

Another potential field for cooperation and joint activity could be a comprehensive analysis of on-board consumption induced by CCAM features compared to the overall benefits of a CCAM system (for instance, gain in traffic efficiency).

Cooperation between the CCAM Partnership and DUT Partnership

DUT - Driving Urban Transitions - is a Co-funded Partnership in Horizon Europe, addressing urban transitions with a cross-sectoral and integrated approach. It includes the transformation of the urban mobility system as one of three pillars in sustainable urban development. Connecting the two initiatives CCAM and DUT allows to build a European approach for the implementation of CCAM, ensuring that its technologies, infrastructures, services and systems are developed with a sound understanding of their implications on the wider urban context. Urban-related results and issues developed and identified in the CCAM Partnership could be considered and taken up within the DUT Partnership, to investigate the wider consequences and potentials of CCAM solutions for urban planning and management. On the other hand, the DUT programme could also support CCAM in mobilising a wider set of actors in the participating countries, contributing to testing and piloting in cities and urban areas with different local conditions, covering some aspects related to governance, the role of CCAM in integrated mobility systems, behavioural issues and needs, as well as relationships to other sectors and systems (e.g. energy).

Potential fields for cooperation:

- CCAM-related infrastructure demands, solutions and their impacts on other urban infrastructures.
- Fleet and traffic management concepts developed in CCAM could be identified and tackled in cooperation with DUT to investigate relationships with other mobility modes.
- Aspects of governance and management, urban planning issues, user behaviour and societal needs, including public authorities' priorities .
- Large scale demonstrations on urban logistics or last-mile delivery could be connected
- Opportunities to assess CCAM solutions and approaches in a wider context, e.g. for other sectors and stakeholder groups.
- Knowledge sharing and learning to support capacity building and joint dissemination and outreach.

Cooperation between the CCAM Partnership and KDT Partnership

KDT – Key Digital Technologies (now Chips JU) – is the Joint Undertaking succeeding the ECSEL Joint Undertaking of Horizon 2020. Its focus is on Electronic Components and Systems as enabling technologies for multiple application fields including mobility. Therein, enabling affordable, automated and connected road mobility is a high-priority R&D&I area. Moreover, KDT shall support the validation and certification through digital innovation for safety, security and comfort of (artificial) intelligence embedded in vehicles. The focus topics of KDT is mostly on providing the Hardware and Software components, building blocks while their customised integration, verification and optimisation is within the CCAM Partnership.

The 2023 Work Programme of KDT contained two automotive focus call topics supporting for two significant elements of the Software Defined Vehicles Initiative (SDV): A European automotive hardware platform and a European open-source automotive software platform.

A complementing call topic of the CCAM Partnership, has been included in the 2024 Work Programme, namely: Centralized, reliable, cyber-secure & upgradable in-vehicle electronic control architectures for CCAM connected to the cloud-edge continuum (HORIZON-CL5-2024-D6-01-01).

The software platform will build an open reference architecture with standardized interfaces, touchpoints, data formats to allow abstraction between layers, a reference implementation and piloting with open-source components and toolboxes, including a toolchain covering the whole product lifecycle and an ecosystem for developers (skills). These reference architecture/implementation and standard interfaces will be open-source for European actors but not open-access for the whole world. The proof of concept for this application platform shall be demonstrated with standardized applications of CCAM functions in the coming calls of the CCAM Partnership.

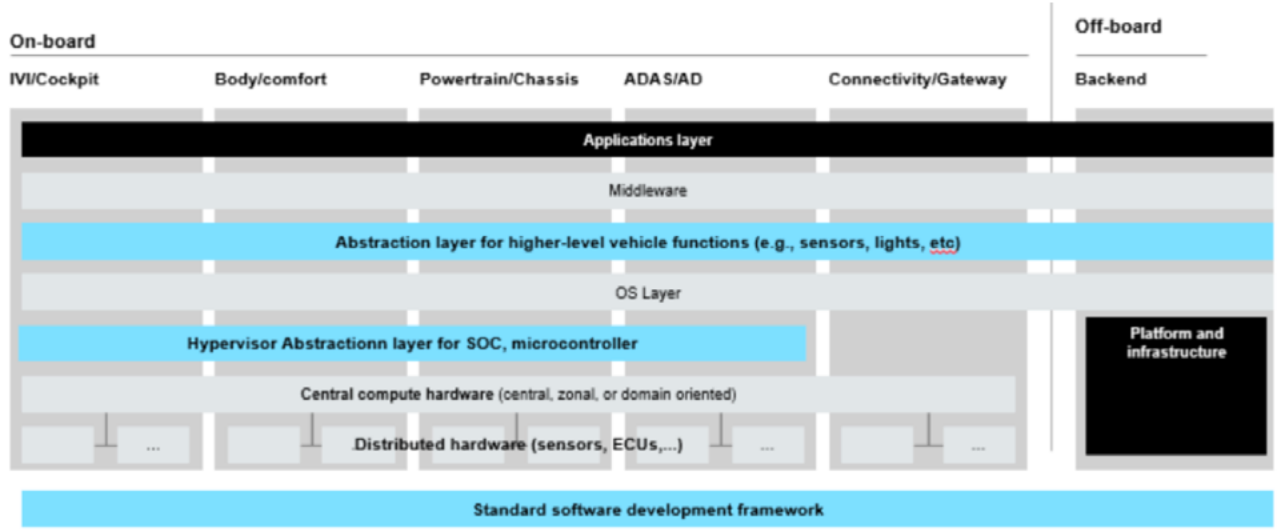
Further potential fields for cooperation

- Sensors, communication devices, actuators, controllers and algorithms or AI, their adaption to the requirements of e.g. a certain automation level or ODD, is part of CCAM. Testing and validation of such control systems (methods, tools, platforms), and particularly their self- learning parts, in view of relevant traffic scenarios, whether in real world or virtually, is a matter of CCAM.
- Hard- and software-based methods of shielding, tamper proofing and encryption ensuring cybersecurity between vehicles, the digital infrastructure and communication networks is part of KDT and adapted to and applied to the specific Use Case of CCAM is part of the CCAM Partnership.
- Active safety and assistance systems supporting CCAM with sensors, actuators and controls are to be developed within KDT. Reliability levels of the components required for accident avoidance should be assessed in CCAM with a feedback loop to KDT.
- Co-design of interfaces between software and hardware architectures in view of increased decoupling.

The concept paper from DG CONNECT issued in February 2023, define the path towards the vision of a 'European Software Defined Vehicle (SDV) Platform'.

As vehicles become autonomous, electric, connected and service-orientated software is playing an increasingly important role in managing their operations and enabling new features. The software platform (e.g. operating systems, middleware, etc.) between hardware and applications, including the integration with the cloud, plays a key role in this new paradigm.

These transformations are putting the leadership and competitiveness of the European automotive industry at risk. The next few years are critical to close the gap with new non-EU OEMs and tech companies. Software complexity is rising sharply, driven by more complex functionalities and a lack of



The first joint effort takes place with a focus project call on the SDV, managed by the Key Digital Technologies Joint Undertaking (KDT JU). The KDT JU should become the Chips Joint Undertaking in 2023 under the European Chips Act.

Potential fields for cooperation:

- Cooperation with the KDT JU to ensure that the CCAM partners are fully involved in the preparation and first implementations of this European SDV platform
- nclude relevant CCAM use cases within the first applications to be implemented and evaluated with the new European SDV platform in the KDT JU project call
- Anticipate the integration of open source RISC-V architectures in the vehicle control units

Cooperation between the CCAM Partnership and The Smart Networks and Services - Partnership

The SNS - Smart Networks and Services - Partnership proposal has as one of its objectives to enable the full digitisation of vertical industries. CCAM was identified as one of the main vertical domains (besides domains like healthcare, media, smart manufacturing, energy, smart cities). The 6G Infrastructure Association (6G IA), has already ongoing collaboration on the CCAM field with stakeholder associations such as ERTICO, GSMA and 5GAA which are also involved in the CCAM Partnership. The 5G CAM Working Group is also established as a means of supporting 5G for Connected and Automated Mobility (CAM) activities funded under EU Programmes covering both R&I and deployment activities For CCAM systems which rely on connectivity for safety-critical functions, the connectivity context will have to be included in the validation methodologies. After various cooperation initiatives from both sides, it is commonly understood, that the research fields of CCAM rely on the deployment of existing SNS technologies, which had been researched under previous programmes already. The dialogue should thus enable the exchange on potential CCAM requirements towards the validation of advanced 5G features for CCAM, and the development of 6G.

Cooperation between the CCAM Partnership and the Partnership on AI, Data and Robotics

Increased computing power, the availability of large amounts of data and progress in algorithms, smart devices and smart robots, are shaping Artificial Intelligence (AI) as one of the most strategic technologies of the 21st century. The SRIDA of the Partnership on AI, Data and Robotics mentions several topics linked to CCAM and more widely to mobility. Based on this and on discussions with representatives of the Partnership, potential fields for collaboration are identified and incorporated. The Partnership on AI, Data and Robotics can be seen as a horizontal Partnership, rather sector-agnostic, whereas the CCAM Partnership is a vertical one. The fields of collaborations are at their intersections, and will concern the development of sector-agnostic innovations into Use Case and sector specific innovations.

The development of CCAM solutions builds upon the progress and directions taken in a number of key technologies addressed by the AI, Data and Robotics Partnership. These are linked to the CCAM Cluster 2 Vehicle Technologies, and to Cluster 5 Key Enabling Technologies. The CCAM Partnership aims at a fast application and uptake of new and emerging knowledge fields identified and developed within the AI, Data and Robotics activities.

After various cooperation initiatives from both sides, it is commonly understood, that the research fields of CCAM rely on the deployment of advanced AI technologies, which are being researched under previous programmes already. Discussions included to more specific application of such AI technologies for CCAM use cases, and how these technologies can help to advance in addressing societal needs including reduced energy consumption for AI based applications like perception, world modelling, risk assessment and actuation of safety features.

Cooperation between the CCAM Partnership and Photonics21 Partnership

The European Technology Platform Photonics21 represents the photonics community of industry and research organisations. Photonics21 activities, addressing developments of key enabling photonics technologies, could potentially benefit from cooperation with CCAM projects focusing on system integration, development of sensor-fusion solutions for environment perception, validation and other pre-deployment activities. After various cooperation initiatives from both sides, it is commonly understood, that the research fields of CCAM rely on the deployment of existing photonics technologies, which had been researched under previous programmes already.

Cooperation between the CCAM Partnership and the Transforming Europe's Rail System Partnership

Transforming Europe's Rail System is an institutionalised public-private partnership (iPPP) in Horizon Europe. It is the follow-up of the Shift2Rail Initiative implemented in Horizon 2020. The objective of the new rail partnership is to enable the European rail network to be a crucial part of the Green Deal policy towards an environmentally friendly and energy-efficient mobility. Dependability, resilience and service quality will be key objectives to fulfil the goal of being a core part of a competitive and resource-efficient multi-modal European transport network.

Even though the partnerships CCAM and Transforming Europe's Rail System do focus on different transport modes, they have points of contact in various topics. On the one hand, to enable a multi-modal transport chain, the future rail system needs to be interoperable with the mobility services developed in CCAM. Especially in the urban environment, where trams and LRT share the same space with automated vehicles. So, cooperation should focus on exchanging and transferring knowledge by e.g. interchange groups for similar action areas in both partnerships. This could include cooperation and possible alignment of methodologies to evaluate societal aspects and user needs, cooperation on urban large scale demonstration like mobility hubs, etc. andjoined dissemination to reach a wider interested public.

Cooperation between the CCAM Partnership and the Clean Aviation Partnership

Clean Aviation is an institutionalised public-private partnership (iPPP) in Horizon Europe. It is the follow-up of the Clean Sky Initiatives implemented in FP7 and continued in Horizon 2020. Clean Aviation's goal is to enable climate-neutral aviation by 2050 through zero- and low-emission technologies. Hereby, Clean Aviation will contribute to the EU policy priorities, especially the Green Deal. Following the draft Clean Aviation SRIA, Clean Aviation will target regional and short-range flights as well as medium and long-range flights by suitable propulsion solutions and aircraft designs.

The purpose of linking CCAM and Clean Aviation is to gain from experience and findings in similar research fields. In several fields CCAM and Clean Aviation have to face the same challenges. Besides the planning of large scale demonstrations, e.g. airports as part of the road network, both partnerships will use the opportunities of digitalisation and thus should exchange on how to address its challenges.

Cooperation between the CCAM Partnership and the Integrated air traffic management (ATM) Partnership

Integrated ATM is an institutionalised public-private partnership (iPPP) in Horizon Europe. It is the follow-up of the SESAR Joint Undertaking implemented in FP7 and continued in Horizon 2020. The goal of the European Partnership on European Partnership for Integrated ATM is to achieve a digital transformation of air traffic management in order to make the European airspace the most efficient and environmentally friendly in the world. This will support the competitiveness and recovery of the European aviation sector in a post-coronavirus crisis Europe. Focusing on e.g. improving connectivity, air-ground integration and automation, increasing flexibility and scalability of airspace management and safe integration of drones there are several fields in which CCAM and Integrated ATM sameshould exchange how to tackle common challenges.

Urban Air Mobility (UAM), brings the ATM Partnership and the CCAM Partnership (and also the DUT partnership) closer to each other's scope of work as urban, peri-Urban and possibly highway areas are expected to host 'mobility hubs', servicing, among other modes, also drones. The latter, although mostly connected to freight and not passenger mobility yet, will have to offer services that are integrated in traffic management within the CCAM system. The CCAM Partnership will take into consideration the interfaces to these modes as they are expected to form part of the multimodal options offered under the CCAM mobility services.

Made in Europe PPP

The Made in Europe (MiE) PPP is the manufacturing partnership with the European Commission under the Framework Programme 'Horizon Europe' (2021_2027).

The MiE partnership is the voice and driver for sustainable manufacturing in Europe based on joined expertise and resources. It boosts European manufacturing ecosystems towards global leadership in technology, towards circular industries and flexibility. The Partnership contributes to a competitive, green, digital, resilient and human-centric manufacturing industry in Europe. It is at the center of a twin ecological and digital transition, being both a driver and subject to these changes.

Potential fields for cooperation:

- Automated Valet Services extended to the industrial part of the vehicle life cycle
- Repair and remanufacturing of CCAM electronic components and systems (ECS)
    - Tracking of failures in operation from the diagnostic software module to enable an efficient ECS

- repair/remanufacturing process
- Traceability of the original or repaired/remanufactured ECS to perform a given ODD, potentially linked to the future Digital Product Passport (DPP)

- Domain transfer for sensors, robotized systems, connectivity, human-machine interactions, perception, localization

The European Union Agency for Cybersecurity (ENISA)

The European Union Agency for Cybersecurity (ENISA) is the Union's agency dedicated to achieving a high common level of cybersecurity across Europe. ENISA contributes to EU cyber policy, enhances the trustworthiness of ICT products, services and processes with cybersecurity certification schemes, cooperates with Member States and EU bodies, and helps Europe prepare for the cyber challenges of tomorrow. ENISA published in 2021 a report on Recommendations for the security of CAM.

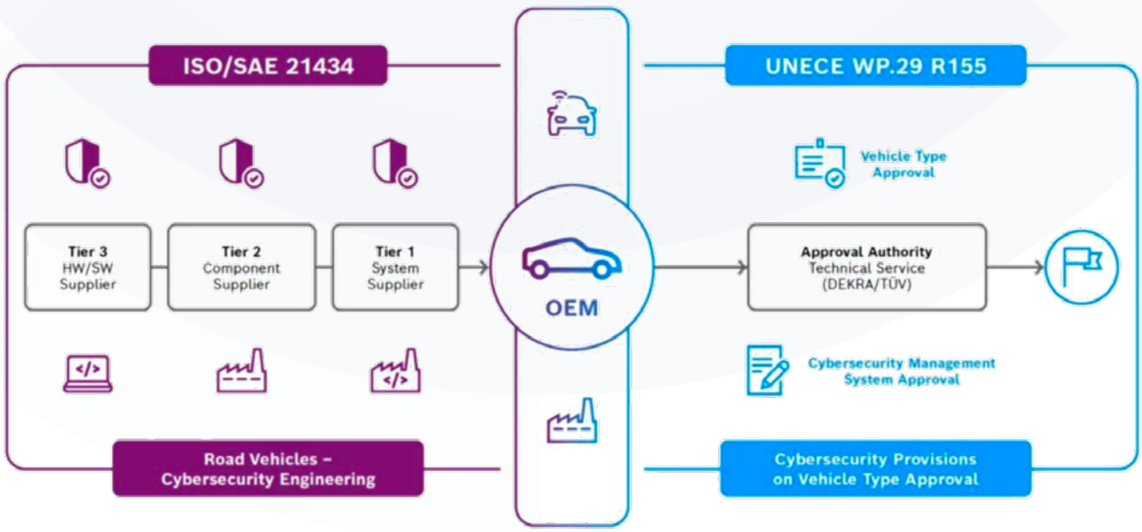
The UNECE Regulation No. 155 on Cyber Security and Cyber Security Management Systems (CSMS) is the first international regulation governing vehicles' cybersecurity. It introduces, among others, audit related provisions that allow the assessment of the robustness of the cyber security measures implemented by manufacturers and the way manufacturers and their suppliers are able to mitigate cybersecurity related risks as well as obligation to perform risks assessments and to keep them current. It also imposes a number of requirements, including the obligation to monitor and report on incidents. It is referred to in UNECE Regulation No. 157 (Automated Lane Keeping Systems), given that automated driving systems must be appropriately protected against cybersecurity risks. In the European Union, the regulation is mandatory for all new vehicle types from July 2022 and will become mandatory for all new vehicles produced from July 2024.

The ISO 21434 specifies engineering requirements for cybersecurity risk management regarding concept, product development, production, operation, maintenance and decommissioning of electrical and electronic systems in road vehicles, including their components and interfaces.

The link between ISO21434 and UNECE R155 is illustrated in the picture below (source: Bosch)

Potential fields for cooperation:

- Cooperation with ENISA and their cybersecurity eco-system partners for the exchange of best practices, updates on threat landscape, and sharing on most efficient mitigation measures
- Contribution to ENISA next report on recommendations for the security of CCAM



Cities Mission

The EU Mission: Climate-Neutral and Smart Cities (in short: Cities Mission) is a novelty of the Horizon Europe research and innovation programme. EU Missions are a new way to bring concrete solutions to some of the greatest challenges. They have ambitious goals and will deliver tangible results by 2030. The Cities Mission will involve local authorities, citizens, businesses, investors as well as regional and national authorities to:

- Deliver 100 climate-neutral and smart cities by 2030
- Ensure that these cities act as experimentation and innovation hubs to enable all European cities to follow suit by 2050

As foreseen in its implementation plan, the Cities Mission takes a cross-sectoral and demand-led approach, creating synergies between existing initiatives and basing its activities on the actual needs of cities.

In the Horizon Europe Work Programme 2023 one of the topics was created in cooperation between the Cities Mission, CCAM Partnership, and 2Zero Partnership. The title of this multidisciplinary Horizon Europe call is: "Co-designed smart systems and services for user-centred shared zero-emission mobility of people and freight in urban areas" (HORIZON-MISS-2023-CIT-01). The topic has in the scope to support cities in their acceleration in transitioning to climate neutrality. It is not an easy task as citizens, logistics and delivery stakeholders, urban planners, transport operators, and technology providers should jointly exploit the combined potentials of electric, automated, and connected vehicles as well as integrated and shared people mobility and freight transport in their planning and actions. It requires a mutual understanding and alignment of the opportunities of existing technical solutions from the CCAM and 2Zero Partnerships and of needs identified by users and cities striving for the Mission target of climate neutrality.

CIVITAS

CIVITAS is an initiative of the European Commission established in 2002 to help achieve the EU's ambitious mobility and transport goals, and in turn those in the European Green Deal. It does this by acting as a network of cities, for cities, dedicated to sustainable urban mobility. Since its launch in 2002, CIVITAS has advanced research and innovation in sustainable urban mobility and enabled local authorities to develop, test and roll out measures via a range of projects. Some 20 living lab projects have been funded between 2002 and 2022, involving more than 90 cities.

A series of ten thematic areas underpin the activities: active travel; behavioural change and mobility management; clean and energy-efficient vehicles; collective passenger transport and shared mobility; demand and urban space management; integrated and inclusive planning; public participation and co-creation; road safety and security; smart, sustainable, connected and shared mobility; and urban logistics.

Link with CCAM: there are several CIVITAS thematic areas overlapping with CCAM, notably, collective passenger transport and shared mobility; road safety and security; smart, sustainable, connected and shared mobility; and, urban logistics. In addition, CCAM developments and deployments could benefit from other activities, like co-creation. Given the potential complementarities, it would be worthwhile exploring greater collaboration with the CIVITAS initiative.

Other EU programmes

Supporting synergies between Horizon Europe and other EU programmes can turn innovations into (commercial) successes. Funds are greatly needed for the implementation phase. FOTs in Living Labs will lead to user acceptance and business cases, but after innovation is demonstrated, there is still a need for implementation. Many opportunities for CCAM innovation uptake fundings have been identified in several workshops in 2022:

- The Connecting Europe Facility (CEF) ITS call, helping to reach similar services along the whole TEN-T network
- The Digital Europe programme to build and deploy the digital capacity. It includes, among others, Artificial Intelligence, cybersecurity, and the common European mobility data space
- The European Investment Bank (EIB) to support innovations in intelligent transport systems, safe system approaches, and resilience of transport infrastructure among the target sectors
- The European Innovation Council (EIC) Accelerator for start-ups and SMEs to scale up with high-impact innovations that have the potential to create new markets
- The European Institute of Innovation and Technology (EIT) Urban Mobility to demonstrate new solutions as support to cities
- The RAPTOR challenges – the competition to create and test solutions to niche urban issues
- The Recovery and Resilience Facility (RRF) to support initiatives that go beyond research and reach out to deployment of enablers of future CCAM services.

In fact, synergies by design are needed to move from research results to deployment. Planning ahead on what to do next with the upcoming research results is crucial – the bigger picture must be seen.

Making CCAM solutions ready for deployment requires that R&I, standards and regulation advance in a synchronised way.

To further develop the coordination and cooperation with other partnerships and programmes, clusters of the CCAM Partnership have their role in this context

Table 7: The CCAM Clusters involvement in cooperation with different Partnerships/programmes

Coordination/ Cooperation	2Zero	KDT	ATM	DUT	AI, Data and Robotics	SNS	Rail/Air/ Waterborne
Cluster 1	Joint call in cities mission, further joint activities	Use cases comparison			AI & data usage	Use cases comparison	use cases comparison
Cluster 2	Software defined vehicle calls	Software defined vehicle calls			AI use cases	Connectivity technology	
Cluster 3					Use of related tools		
Cluster 4			Interfaces with other modes (UAM)	Fleet/ traffic management, other mobility modes Societal needs, urban priorities		Infrastructure usage, requirements	traffic management interface
Cluster 5		Software defined vehicle, new digital technologies and facilitating hardware			AI and data usage	Connectivity technologies, IoT	
Cluster 6	Joint public acceptance, environmental impacts			Societal needs			Cross-modal opportunities
Cluster 7	Enable coordination/ cooperation	Enable coordination/ cooperation	Enable coordination/ cooperation	Enable coordination/ cooperation	Enable coordination/ cooperation	Enable coordination/ cooperation	Enable coordination/ cooperation

11. Annual planning and work process

11.1. Approach of stakeholder involvement and activities planning

To deliver on the objectives of the Partnership, it will be necessary to assess and update on a regular basis the priorities and planned activities. The SRIA was developed in a comprehensive process engaging with all relevant stakeholders, as described in chapter 2. Broad stakeholder involvement via the Partnership association will be the basis for identifying priorities and defining the activities with all constituent entities, including Member States representatives. This consultation process will be the basis for the work: setting up each year a number of activities and meetings to support the assessment, setup and monitoring of the Partnership activities and objectives. All relevant stakeholders will be involved through an open membership approach of the Partnership association, with a proactive strategy to encourage further membership.

The development of the SRIA was based on a co-creation approach engaging the multi-sectoral stakeholder community. Even though the SRIA R&I actions are defined on a long-term basis, they are based on technological and socio-economic realities that will continue to evolve, making it imperative that its expected results and impacts are monitored continuously: this assessment will feed the definition of the next research priorities and additional activities.

11.2.Process, content and timing for the annual workplans

The objectives of the SRIA will be translated into annual workplans to be discussed and agreed in the Partnership Board, by the delegates of the stakeholders together with the European Commission services. The governance of the Partnership Board is defined in the Memorandum of Understanding signed between the European Commission and the Partnership Association, completed by rules for procedures. The governance of the Partnership association is defined by its own Statutes, setting up the nomination process and work principles for the delegates representing the association in the Partnership Board. Important principles have been set to guarantee representativeness and openness: delegates will be elected from all the different member categories, and will act not to represent only their own organisation but to represent their stakeholder category and the association as a whole.

The annual workplan will propose actions for the following year: including the preparation of research recommendations for the Work Programme, and also the identification of additional activities to be done beyond EU projects. These additional activities, as defined in the Memorandum of Understanding, will contribute to achieve the objectives of the Partnership e.g. further testing and demonstration, support to standardisation or harmonisation, dissemination and support to societal uptake, etc., as explained in chapter 8. Furthermore, outcomes and results of ongoing R&I projects should be collected on a regular basis to feed the process with latest news: information from projects will be collected, with the common knowledge base being the key instrument and source for this assessment.

The annual workplans will therefore include the following activities:

On a regular basis: inputs from the running CCAM projects to build the State of the Art and lessons learned. This process should be conducted with the support of the coordination projects from Cluster 7, which are essential tools for the collection of knowledge, State of the Art and methodologies.

When requested by the European Commission and at least every two years: discuss the next R&I priorities for CCAM, including expected impacts and objectives, by providing detailed recommendations for topics to be included in the Horizon Europe Work Programmes. Each of the 7 CCAM Clusters will prepare content for these topics, to be discussed also in the General Assembly meetings, with all members invited to participate in this process. Member States organisations will be involved in this process directly through their membership in the association. Recommendations will also be presented in the States Representatives Group. These R&I priorities for the next Work Programmes will be developed together with the European Commission services within the Partnership Board: the delegates of the association will present to the Partnership Board the input prepared within the association, to discuss with the EC services with the goal of reaching a common understanding. The text of the R&I topics will be finalised and processed by the European Commission into the Horizon Europe Work Programmes.

On an annual or bi-annual basis, according to the reporting methodology described in the Memorandum of Understanding:

a) Assess the progress done towards the Partnership objectives, using the Key Performance Indicators (KPIs) described in chapter 6.

b) Report on the functioning of the Partnership, including on openness, transparency, collaboration and synergies with other European Partnerships and initiatives.

c) Plan and report the additional activities done beyond EU projects (as described in chapter 8.2 and in the MoU): develop every year a plan of which upcoming additional activities can support the objectives of the Partnership, and then report annually which of these additional activities have been done, including qualitative assessment and quantitative data whenever possible.

d) Provide information on investments in operational activities (as described in the MoU): investments spent beyond the work foreseen in the SRIA, including public and private investments mobilised to exploit or scale-up CCAM. This is used to calculate the leverage effect of the Partnership.

e) Develop "impact case studies": success stories that can be used to highlight prominent results or lessons learned from specific projects/activities, or highlight follow-up using other instruments.

The planning and reporting of additional activities and investments in operational activities will respect confidentiality and competition requirements.

11.3. Process and timing for updating the SRIA

The SRIA provides the strategic framework for preparing future activities within the Partnership. In order to consider recent developments and rapid technological progress (i.e. of disruptive nature), the SRIA will be updated during the lifetime of the Partnership to reflect any major technological advancement, new emerging challenges, or evolving societal needs. So, even though the SRIA at hand is covering the full duration of the Partnership, an evaluation during the Partnership lifetime will be necessary.

This review and updating process will be done in full openness, involving all the members of the Partnership, again in a co-creation approach. The coordination activities from Cluster 7 will provide the knowledge on latest project results and achievements, and all Clusters will support the evaluation by providing relevant expertise on the different R&I fields. The European Commission services will participate to the evaluation. Member States Representatives will be involved through the States Representatives Group. All members of the Partnership will be consulted in the drafting of the updated SRIA version, and a public consultation will be organised, to allow also non-members to provide their views. The updated SRIA will be presented to the General Assembly of the Partnership association for endorsement by the stakeholders, and to the Partnership Board for agreement with the European Commission.

Co-funded by the European Union

EUROPEAN PARTNERSHIP

CCAM

CONNECTED, COOPERATIVE & AUTOMATED MOBILITY

V2.4 | 18/01/2024

CCAM
Avenue de Cortenbergh 66,
1000 Brussels
marzena.jougounoux@ccam.eu
ccam.eu