# Developing EU-CEM: A Common Evaluation Methodology for Evaluating Co-operative, Connected and Automated Mobility

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**Abstract.** Co-operative, Connected and Automated Mobility (CCAM) is of increasing interest to the transport community across the world, though is still maturing. The Horizon Europe project FAME is developing a European framework for testing CCAM on public roads. As part of this, a common evaluation methodology (EU-CEM) is being developed, which provides guidance on how to set up and carry out an evaluation or assessment of direct and indirect impacts of CCAM solutions on different user groups and wider society. Objectives include ensuring that evaluations can be complementary planned with results that are easy to compare, as well as establishing a common vocabulary to support projects in the CCAM community. This paper sets out how the EU-CEM is being developed and embedded into CCAM research in Europe, with a particular emphasis on how the project has adopted an agile and iterative approach to the CEM development alongside meaningful and sustained engagement with stakeholders.

**Keywords:** CCAM · Evaluation · Impact Assessment

## 1 Introduction

In a world of increasing digitalisation and connectivity our transport systems are undergoing dynamic change. Currently in its early stages as a viable transport option, Co-operative, Connected and Automated Mobility (CCAM) is considered by many to offer opportunities for a safer, more efficient and more equitable alternative to conventional modes. However, without large scale deployment, there is a lack in empirical evidence from impact assessment and evaluation studies to support these claims.


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The EU introduced their Cooperative Intelligent Transport Systems (C-ITS) strategy in 2016 [1], which set out their goals towards deployment and regulation of CCAM. This was followed in 2018 by a strengthened commitment to CCAM through a strategy for mobility of the future [2], where a role of CCAM in shaping the future of transport is recognized alongside a vision to be world-leader in CCAM deployment through an ambitous research and innovation programme and development of a legal framework. Part of this was a commitment to establish a single EU-wide platform to coordinate testing and deployment of CCAM. The 2020 Sustainable and Smart Mobility Strategy [3] made a policy ambition of large scale CCAM deployment by 2030. Set within this landscape, the Horizon Europe programme has funded the FAME [4] project to establish a European framework for the testing of CCAM on public roads. Building on the previous projects ARCADE (2018–2022) [5], CARTRE (2016–19) [6], VRA (2013–16) [7] and the three FOT-Net projects (2008–2016) 8], FAME will develop tools to facilitate collaboration between CCAM stakeholders.

In this paper we will present one component of this, the development of a European Common Evaluation Methodology (EU-CEM) that provides guidance on how to set up and carry out an evaluation or assessment of direct and indirect impacts of CCAM solutions on different user groups and wider society.

## 2 Background

The EU-CEM builds on experience from the widely adopted FESTA methodology for Field Operational Tests (FOTs) [9], which has been successfully used in large-scale European and national projects. However, FESTA has recognised gaps with specific research boundaries when it comes to CCAM, such as achieving a realistic user experience with prototype vehicles, agreed principles for data-sharing, adaptation to local circumstances of pilot sites and standardised future scenarios. FESTA was originally developed for evaluating driver support systems and other intelligent in-vehicle systems that were relatively mature prototypes, providing well-defined functions. CCAM systems and services that are tested in CCAM projects are far more wide-ranging, and often still quite experimental. Automation is often not limited to a specific set of driving tasks but can take over large parts of these tasks or even completely. Also, CCAM is not only related to vehicles but also services making use of the vehicle to be evaluated.

Automation in road transport will have wide-ranging implications. FESTA addresses impact assessment in the areas of safety, efficiency, environment, mobility, safety and user uptake. However, CCAM may have far wider impacts, not only on the traffic system and scope of impacts but also on society and liveability of cities and regions. The traditional impact areas are no longer sufficient for determining the full impact of road automation. The Impact Assessment Subgroup of Trilateral Working Group of Automation in Road Transportation[1] identified direct impact areas as safety, vehicle operations, energy/emissions and personal mobility, and as indirect areas network efficiency, travel behavior, public health, infrastructure and land use, and socio-economic impacts. These indirect impacts on societal level are difficult to establish. FOTs and other experiments

[1] The group is an initiative of the European Commission, the United States Department of Transportation and the Japanese Ministry of Transportation.

provide important information of driving behaviours but these are usually not sufficient to determine wider impacts on a societal level. Other data are needed, for example about future demographics, as well as simulations using different penetration rates of CCAM. In consultation with stakeholders and projects in the ARCADE and FAME projects, a wide range of needs for guidance and recommendations on performing studies and impact assessment were identified, which are not provided in the FESTA methodology. In addition, there is a growing need to harmonize (or even standardize) the way in which studies on CCAM are performed in order to get a more nuanced picture on what CCAM will mean for society in the future. This includes having common elements in projects such as vocabulary, key performance indicators, common research questions, and standardized ways of describing scenarios, use cases and Operational Design Domain (ODD).

## 3 Methodology for EU-CEM Development

The overall scope of the EU-CEM is to provide guidelines and share best practices for planning, conducting and reporting of CCAM evaluation, especially impact assessment. The EU-CEM will be written down in the form of a handbook. It will provide a complete plan that explains what is needed to plan and carry out an evaluation of direct and indirect (wider socio-economic) impacts, and which is firmly anchored on field experiments combined with a wider scope aiming to reflect impacts beyond what can be tested on roads. Guidelines are given on how to conduct impact assessment of (an assumed) mature CCAM technology while the field experiments are done with prototypic systems. An important ingredient of the EU-CEM is a list of commonly used key performance indicators and guidance on how to define these indicators for specific evaluation areas. To complement this, a common vocabulary (taxonomy) of CCAM terms is being developed.

The EU-CEM development commenced in July 2022 and the initial content has been developed iteratively by the project team through a series of workshops and engagement with stakeholders involved in previous and ongoing CCAM projects. As a timely and state-of-the-art tool for CCAM evaluation, the EU-CEM is being developed in line with the following high-level principles:

- **Guiding star.** To provide a common evaluation methodology for all CCAM tests, setting minimum requirements for evaluation.
- **Collaboration.** To provide evaluation guidance inspired by lessons learned and best practices of CCAM tests.
- **Comply-or-explain.** To provide guidance which should be followed by projects, and if that is not possible or desirable projects will be encouraged to provide explanations of the motivation for different choices.
- **Agility.** To provide recommendations to encourage agile ways of working in developing the project evaluation plans.
- **Flexibility.** To provide guidelines allowing for flexibility in adapting the EU-CEM to projects' specific evaluation needs.

The EU-CEM targets large scale projects but can also be applied to smaller studies. The focus will be on:

- Automation of road transport of people and goods, all vehicle types (specifically cars, trucks, shuttles, buses);
- Higher-level driving automation (SAE level 3 and higher), with and without connectivity;
- Use cases on public roads, likely with specified operational design domain (ODD), operating in mixed traffic.

Even if this is the focus, the framework and CEM will cover testing of e.g. safety critical scenarios on test track to supplement the on-road testing, or driving in confined areas, when the automated vehicle interacts with humans or non-automated vehicles.

### 3.1 EU-CEM Taxonomy

To minimise confusion and misunderstandings, a taxonomy was developed. The EU-CEM taxonomy aims to provide a common language set for the EU-CEM develop-ment and in light of this, for the CCAM large-scale piloting, demonstrations and evaluations. To achieve high readability, the taxonomy has been visualised and made navigable with an ontology software. This depicts the multiple relationships between concepts and provides easiness in using the EU-CEM when doing a CCAM evaluation.

### 3.2 EU-CEM Inventory

The goal of the inventory was to provide the CEM chapters with additional input and context which are not easily found in literature. This was done by comparing CCAM evaluations, their approaches, methodologies, best practices and things to avoid. Furthermore, the findings from the inventory highlight the need for a CEM, through examples of knowledge gaps or deviations from initial evaluation plans, which can aid future CCAM evaluations. The inventory is based on four sources;

1. An analysis on 14 recent CCAM evaluations, in which projects were analyzed on (among others) used methodologies, use of research questions and hypotheses, types of use cases, ODDs, impact areas (direct/indirect), etc.
2. Out of the 14 evaluation plans, 7 interviews were organized with the project managers in which further context was gathered, such as best and worst practices.
3. A FAME workshop on methodological challenges and recommendations.
4. An ARCADE gap analysis including a long list of methodological challenges.

### 3.3 EU-CEM Chapters

The EU-CEM is set out in different chapters to guide the project team (especially those responsible for evaluation) through the different phases of carrying out the evaluation of a CCAM large scale demonstration from planning of the proposal to evaluation of the processes and outcomes when the project ends, as set out in Fig. 1.

The proposal preparation phase provides guidelines for the preparation of the project proposal, laying a strong foundation for successful evaluation. It covers the development of the project structure, setting up the project governance as well as scoping and setting up of the evaluation to align with the main aims of the proposed project plan.

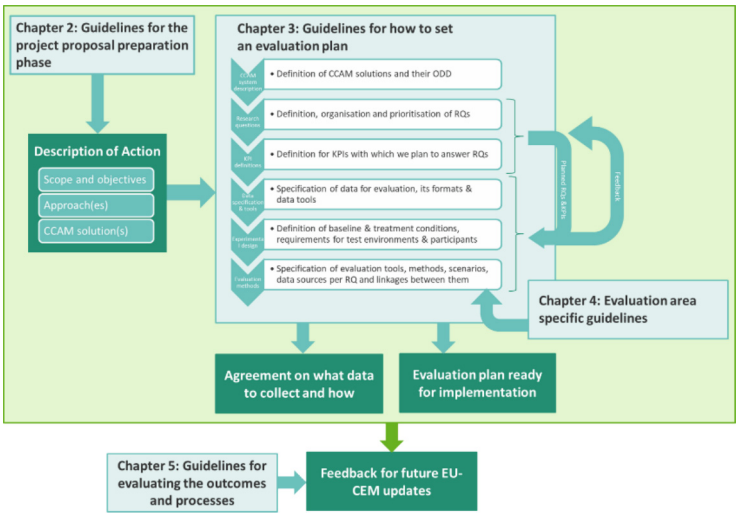


**Fig. 1.** EU-CEM Main Chapters

Detailed planning takes place at the beginning of the project. The EU-CEM provides guidelines for how to set a solid evaluation plan, including the iterative process of setting up research questions, KPIs, data requirements, experimental design and evaluation methods. Once the experiment is set up, the data collection phase can begin following what was agreed on the specification of data collection for evaluation and related tools. If something unexpected happens, the governance structures set to ensure good dialogue within the project allows adaptation of the plans in different work packages affected.

The actual final evaluation phase can occur alongside and/or after data collection. The EU-CEM sets out evaluation area specific guidelines on Vehicle (technical functions, driving behavior), Human (user evaluation, personal mobility, quality of life), traffic and transport (services and operations, good logistics, safety, traffic and network performance, energy and environment) and Society (land use, liveability, equity, growth and employment, socio-economics and sustainability).

After the evaluation has been completed, EU-CEM provides guidelines how to assess the processes and outcomes, and identify new practices for future EU-CEM updates or provide feedback on guidelines that should be modified.

### 3.4 EU-CEM Piloting and Validating

From May 2023, the project team hosts online methodology clinics for CCAM projects on a regular basis. Topics cover the need for new tools and evaluation methods, data communication, standardised KPIs, the difficulties of interdisciplinary comparison stakeholder networks and knowledge co-creation with stakeholders and citizens. The EU-CEM will be piloted and validated through engagement with ongoing CCAM projects. In particular, those involved with evaluation within the projects will be invited to in-person workshops and a summer school to learn how to engage with the EU-CEM,

prior to piloting. Learning from these projects and feedback from the pilots will allow refinement and finalization of the EU-CEM.

## 4 Next Steps

The first full draft of the EU-CEM was completed in early 2024, ready to be validated and piloted in actual CCAM projects that need to prepare for an evaluation or impact assessment. Workshops and a summer school were hosted in early 2024 with these projects to provide guidance in its use. The EU-CEM Handbook for CCAM [10] was finalized in May 2025 and is expected to be used by Horizon Europe CCAM projects.

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