

## Developing a common evaluation methodology for CCAM

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### Abstract

The European research and innovation action FAME is developing a *common evaluation methodology* (CEM) that provides guidance on how to set up and carry out an evaluation or assessment of direct and indirect impacts of cooperative and connected automated mobility (CCAM) solutions. The CEM will be part of *European framework for testing [of CCAM] on public roads*. The objectives set for CEM include ensuring that subsequent evaluation results are easy to compare, allowing all projects to benefit from the best methodological practices found. This should maximise the benefits of the evaluation work carried out in this domain. Once the first version of CEM is complete it will be validated and piloted, i.e., applied in actual projects that need to prepare for an evaluation or impact assessment. For good uptake, consensus and CEM community building will be needed, as well as a strategy for the application of CEM in future projects.

### Keywords:

Methodology, evaluation, impact assessment, CCAM

### Background

The Sustainable and Smart Mobility Strategy [1] published by the European Commission in December 2020 foresees that automated mobility will be deployed at large scale by 2030, constituting an important milestone to keep the European transport system's journey towards a smart and sustainable future on track. Connected, Cooperative and Automated Mobility (CCAM) has indeed been seen to have the potential to make transport safer by reducing the number of road fatalities and accidents towards Vision Zero [2]; greener by helping to reduce harmful emissions from transport by smoothening traffic flow and avoiding unnecessary trips and thus supporting the objectives of the Green Deal [3]; and more accessible by ensuring inclusive mobility access for all. Besides technological progress, there are challenges and uncertainties related to the development of CCAM regarding societal, economic, operational and regulatory aspects. To overcome these challenges, an integrated and harmonised approach is very much needed for the evaluation of these systems and services.

To be able to evaluate CCAM in a systematic and rigorous way, a comprehensive evaluation methodology is needed. Over the past decade, experience has been gained on the evaluation of advanced driver-assistance systems and other vehicle information and communications technologies. In order to support the Field Operational Tests (FOT) of these systems, the FESTA methodology for FOTs was developed in 2008 as part of the European FESTA project and described in the FESTA Handbook, which has since been updated many times [4].

The FESTA methodology has been successfully used in large-scale FOTs in European and national projects. Although the latest version of the handbook [4] pays attention to the evaluation of automated systems, the complexity of CCAM requires new approaches besides FOT. CCAM systems are often still prototypes under development, have a variety of functions, and for practical and legal reasons can often not be tested in the form of FOTs, requiring for example safety drivers or limited areas where the systems are allowed to drive [5]. The ARCADE coordination and support action organised a workshop to make an inventory of the methodological gaps that are not addressed by FESTA [6]. Some examples of requirements for a CEM that were identified include:

- Approaches for achieving a realistic and rich user experience with early prototype vehicles.
- Guidelines for study designs enabling generalisation of the results (needed for the impact assessment), taking into account the scale of the test.
- Agreed principles for sharing data between industry and research, taking into account the sensitivity of the data from a business perspective.
- Common performance indicators for assessing the impacts.
- Shared future scenarios for generalisation of impact assessment.

The gaps show the complexity involved in CCAM evaluation, requiring innovative methods and tools. A clear need was identified for more agile evaluation processes, without sacrificing the structured and evidence based approach advocated by FESTA.

The European research and innovation action FAME [7] is tasked with developing a *common evaluation methodology* (CEM) that provides guidance on how to set up and carry out an evaluation or assessment of direct and indirect impacts of cooperative and connected automated mobility (CCAM) solutions. This methodology will be part of the *European framework for testing [of CCAM] on public roads*. The mission of FAME is to establish this European framework for testing on public roads, enable evaluations with a common methodology, engage an active community of stakeholders across the complex cross-sectorial value chain, and capitalise on shared knowledge to improve cooperation, consensus building and data sharing for CCAM testing and large-scale demonstration activities in Europe.

The work of FAME builds on the outcome and recommendations of the CCAM Platform [8], on best practices from tested methodologies such as FESTA [4], and on flagship projects like L3Pilot [9], SAM [10] and Hi-Drive [11]. CEM takes into account the special characteristics of automated mobility studies and different CCAM evaluations. Development of the CEM commenced in July 2022 and is due to be

developed over a three-year period. The CEM development team consists of 10 organisations across nine European countries.

### **CEM development**

Objectives set for the CEM include that it ensures that subsequent evaluation results of different studies using it are easy to compare, and that the evaluations can be planned to complement one another and support meta-analyses. The aim is to allow all projects to benefit from the best methodological practices found. This should maximise the benefits of evaluation work carried out in this domain. The CEM also aims to set a common vocabulary for evaluation studies. With the comply-or-explain principle, the CEM helps projects to communicate their approaches and findings to the CCAM community. The ultimate objective for the CEM is to support projects so that they can provide high quality results of impact assessment as input for decision- and policy-making.

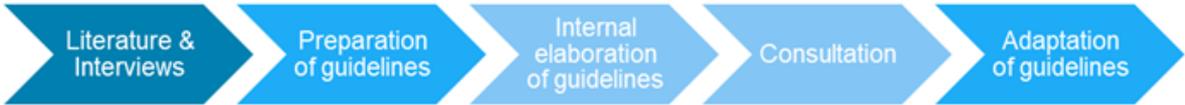
As a timely and state-of-the-art tool for CCAM evaluation, the CEM will be developed in line with the following (draft) high-level principles:

- The CEM provides a common evaluation methodology for all CCAM tests, setting minimum requirements for evaluation – *Guiding star principle*.
- The CEM provides evaluation guidance inspired by lessons learned and best practices of CCAM tests – *Collaboration principle*.
- The CEM provides guidance which should be followed, or the motivation for different choices should be explained – *Comply-or-explain principle*.
- The CEM encourages agile ways of working in developing the project evaluation plan – *Agility principle*.
- The CEM allows for flexibility in adapting it to each project's specific evaluation needs – *Flexibility principle*.

The first step in the development is to elaborate and agree upon the table of contents of the CEM Handbook. Part of this involves consultation with selected stakeholders. Alongside this, an inventory of existing CCAM project methodologies will be compiled by the project team to identify existing synergies and conflicts. A taxonomy of terms will be developed, ensuring a common language is understood by all CEM users. The next step is to formulate the actual CEM. Before finalisation, the CEM will be piloted with ongoing CCAM testing.

According to initial plans, the CEM will be divided into chapters representing five phases of evaluation: proposal, preparation, data collection, evaluation and process evaluation. The work on CEM development will be carried out first by small groups of experts working on the dedicated CEM chapters, who will draft generic guidelines for different steps of the evaluation (steps 1 & 2 in Figure 1). This will be followed by internal workshops (step 3) organised to discuss and elaborate the guidelines with a larger team, and to build consensus. Also, selected experts within the CCAM community will be consulted to collect feedback on the draft CEM (step 4). Where necessary, adjustments to the CEM will

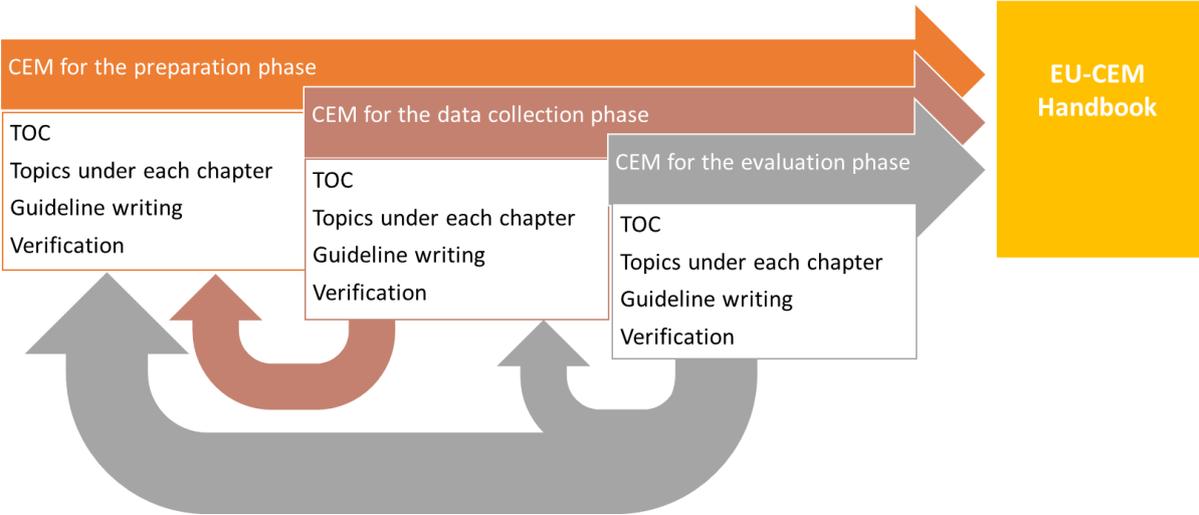
be made based on the feedback received (step 5) to ensure high quality, good understanding and smooth uptake of the final CEM. This process involving discussion and feedback rounds is necessary to deal with the complexity of the material and extent of the CEM. Throughout the CEM development, as well as among the Chapter owners, various team members will be responsible for ensuring the consistency of cross-cutting themes such as ethics and legality or cross-border aspects. Process mapping will also ensure the final usability of the CEM.



**Figure 1 - Overall process for CEM development**

The process of CEM writing is to be kept agile. Specifically, this will mean that all of the planning, writing and evaluation is done iteratively phase by phase (Figure 2). This evaluation step will include verification that

- the guidelines are fit for all CCAM use cases (or as many as possible),
- the requirements of the following steps are met in the preceding steps,
- all chapters are coherent,
- the CEM vocabulary complies with the terms defined in the taxonomy produced by FAME,
- the CEM is compliant with the Data sharing framework produced by FAME.



**Figure 2 – Iterative approach of CEM development**

Linked to the methodology inventory, input from other projects will be sought regarding the role of different evaluation approaches in the assessment, when going from direct impacts to indirect ones that

cannot be measured directly in a pilot or demonstration. These approaches will include an overview of different modelling concepts (e.g. from micro-simulation to land use modelling) which have been or can be used. The methodological input from projects is likely to be specific to the functionalities tested in the project and to the key research questions set for them. Therefore, the CEM development team must identify and then process a large number of these suggested best practice candidates, see if they fit the CEM, and modify them to provide generic guidance that fits the other projects. The team must also ensure that the given guidelines function as a whole. The team must fulfil methodological gaps where no good practices are available, using the team's extensive experience in previous evaluation activities. The CEM needs to expand existing methodologies (such as FESTA) to address more widely the effects on inclusion (different socio-demographic groups, regions, time scales) and sustainability.

### **Resulting CEM**

The likely result of the CEM development, the EU-CEM Handbook, will be a hybrid “blueprint”, i.e., a complete plan that explains how to plan and carry out an evaluation, and which is firmly anchored on field experiments combined with a wide scope of evaluation aiming to reflect impacts beyond what can be tested on roads and can therefore only be marginally supported by field measurements. Guidelines will be given on how to conduct impact assessment of (an assumed) mature CCAM technology while the field experiments are done with prototypic systems.

The CEM will cover all the evaluation steps from evaluation preparation – or even preparation of the evaluation project – to the assessment of wider socio-economic impacts, including aspects like

- personal mobility and use of CCAM solutions,
- safety,
- efficiency and environment,
- land use,
- quality of life and equity,
- growth and employment.

The CEM will provide specific guidelines for different steps in the evaluation, along with practical examples to support understanding and application of the guidance given. It will be ensured that the CEM is fit for all CCAM use cases covered by FAME. The aim is to provide the guidance, as much as possible, in use-case-agnostic form.

An important ingredient of the CEM will be a list of commonly used key performance indicators and guidance on how to define these indicators for specific evaluation areas. Many indicators are already commonly used, but for wider, indirect societal impacts with which decision and policy-making can be supported, relevant indicators need to be identified and described and/or defined for the context of CCAM.

Challenges facing the CEM include aspects like the complexity of CCAM systems/functions, field experiments are costly and the possibilities for data collection are often limited, best practices may be written down but worst practices mostly not, and the CEM should cover many different impact areas with different requirements. Despite all these challenges, the CEM development team must ensure that the application of CEM in assessments will be economic, and that the CEM is feasible to be used in projects with different resources for evaluation. While the evaluation process in FESTA was linear, CCAM calls for more iterations and a smooth process needs to be planned for its evaluation. The CEM must be agile and flexible and allow modular updates later; a balance between agility and validity needs to be found for this.

The CEM will be provided as a handbook (EU-CEM Handbook) but also in the knowledge base of CCAM [12].

### **Outlook**

After completion of the first version of the CEM, it will be validated and piloted, i.e., applied in actual projects that need to prepare for an evaluation or impact assessment. This will be done with selected European and national projects by allowing them to use draft versions of it and collect feedback for its elements. Readers with a project that could qualify for testing the CEM are encouraged to contact FAME's CEM development team.

A summer school or workshop for those involved in CCAM projects with impact assessment, and who are new to this domain, will be organised to evaluate the comprehensibility and ease of use of the CEM. Piloting of the CEM will produce conclusions in a practical setting (of external projects) and recommendations for updates where it is not working as planned or could be enhanced.

For good uptake, consensus and CEM community building are needed, as well as a strategy for the future application of CEM in projects. It is foreseen that future CCAM projects will be asked to follow the CEM in their evaluation.

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