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ARCADE

Aligning Research & Innovation for Connected and Automated Driving in Europe

Micro-FESTA for CCAM pilot projects

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Abbreviations

Term	Description
ARCADE	EU H2020-DT-ART-2018-2019/H2020 CSA project Aligning Research & Innovation for Connected and Automated Driving in Europe, GA number 824251
CCAM	Connected, Cooperative, and Automated Mobility
FOT	Field Operational Test

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Executive Summary

This document presents Micro-FESTA, a condensed methodology to support small pilot projects of Connected, Cooperative, and Automated Mobility (CCAM).

Micro-FESTA is based on the extensive FESTA Handbook for performing Field Operational Tests (FOTs). The small pilot projects that Micro-FESTA targets may not have the scope or resources to make full use of the FESTA approaches. FESTA discusses large-scale testing campaigns that address a number of research questions in order to scientifically assess the broad societal benefits of a tested system. FOTs aim to be naturalistic tests, where the users get to try out the systems in their daily life over a period of months.

This scope of testing is not necessarily the target in pilot projects. Tests could be bound to small operational areas due to infrastructure and similar requirements, or expensive equipment can only be used for a short period at once. However, small pilot projects can offer a significant contribution to gathering knowledge on the effects of road automation.

The principles on which FESTA methodology is built as well as its practical recommendations can support various types of user and vehicle related tests, and is also of value for small projects. FESTA offers a framework with definitions, categories and worked-out examples. It provides helpful checklists for all phases of a field trial project and discusses best practices from past projects. FESTA has been successfully used already in pilot projects of varying sizes, providing both a scientific structure and efficient methods to run the tests.

This document gives an overview of the main steps in the FESTA methodology and comments their role in small-scale testing. This document can also be used as a first introduction to the full FESTA methodology and available materials.

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1. Introduction

1.1. The need for Micro-FESTA

Numerous projects have recently set out to test Connected, Cooperative, and Automated Mobility (CCAM) technologies and services. Automated driving tests are gradually branching out from test tracks to a wider audience. Projects range from large European Field Operational Tests (FOTs) to small-scale pilots. This document targets the smaller-scale efforts, predominantly run by a couple of organisations and taking place in a single city.

In order to support the evaluation of advanced driver-assistance systems and other vehicle information and communications technologies, the FESTA methodology for FOTs was developed in 2008, and updated several times. However, FESTA is focused on large-scale FOTs, and for small pilot projects, a more condensed version was considered useful. A first version of Micro-FESTA was published in 2016. This document is an update, a concise document targeting small pilot projects testing CCAM.

Small pilot projects do not have the scope or resources to make full use of the FESTA approaches. Instead of first considering a wide map of potential society-wide impacts and related research questions, like in FESTA and EU-wide efforts, small projects usually set out with a few practical and operational goals. They carry out tests with limited means, but do not want to come out with limited results or vague lessons. Pilot projects commonly target “learning by doing”, maximising the number of users or duration of their tests, making best use of their resources. Besides gathering test results, projects also aim to promote new technology and introduce them to a wider public. The scope of testing must be selected so that tests can run without problems and good user experience and support can be achieved.

Small pilot projects can offer a significant contribution to gathering knowledge on the effects of road automation. National and local tests often deal with practical deployment issues that may not even come up in EU-level research programmes. There are several questions these projects can help to address:

First, there is the question of *why we want to know the impacts of CCAM* – in other words, the policy and strategic questions; what would policymakers and stakeholders want to do with the results? Knowledge about impacts is needed for several stakeholders to make decisions: where to invest, what to subsidize, what to allow, and what should be prohibited. Industry has to develop business plans and determine how these new technologies and services can best be deployed.

Secondly, *when are we convinced* that positive and negative results are trustworthy – in other words, the evidence question. There are several answers to this:

We could look at the user and societal acceptance. Is automation answering user needs and preferences, is the general public willing to adopt these new ways of transport and change their mobility? Will automation contribute to improve the liveability of cities and regions?

Another way of answering the question is by looking at the business side. Do industry business models predict profit, and are governments subsidizing technological development and implementation?

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We could also ask for scientific evidence: can we find proof that the promises about, for example, improved safety and mobility can be realised? This brings us to the next question: *how do we investigate the effects*, in other words: the methodology question.

Pilot projects and FOTs actually share the main methodological elements: defining the test(s), setting up data collection, recruiting users, analysis of the data and considering the results with stakeholders. Use of FESTA lessons can boost pilot projects in many phases. In particular, reusing existing tools, templates and learning from best practices can significantly speed up test preparations. FESTA offers a scientific framework with its methods, categories and definitions. It provides practical guidelines for each step of testing and helps to define a clear setup and thereby hopefully achieving valid and easy-to-understand results.

This document introduces the key points of FESTA methodology and discusses how they can benefit small projects. At the same time, Micro-FESTA could be used as an entry for people who are newly involved in evaluating automated systems.

1.2. ARCADE

This document has been created by the ARCADE consortium. ARCADE is a Coordination and Support Action under the Horizon 2020 programme Societal challenges – smart, green and integrated transport – Grant Agreement Number 824251. The mission of ARCADE is to coordinate consensus-building across stakeholders for sound and harmonised deployment of Connected, Cooperative and Automated Driving (CAD) in Europe and beyond. ARCADE supports the commitment of the European Commission, the European Member States and the industry to develop a common approach to development, testing, validation and deployment of CAD in Europe and beyond.

ARCADE involves 23 partners from 11 EU members states, 55 associated partners (signed agreements as of June 1st 2020) and many subscribers (newsletter, other interests, joining workshops), jointly forming the CAD network of European experts and stakeholders from the public, industry and research sectors, with international outreach. Associated partners can be organisations from the private or public sector, research, stakeholder associations or individual experts. ARCADE started on October 1st 2018 and has a running time of three years.

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2. The FESTA Methodology

2.1. The FESTA V

The FESTA Handbook draws from experience and knowledge across numerous past Field Operational Tests (FOTs) of vehicle ICT. The latest version can be accessed at https://www.connectedautomateddriving.eu/methodology/festa/.

FOTs are defined as:

> A study undertaken to evaluate a function, or functions, under normal operating conditions in road traffic environments typically encountered by the participants, using study design so as to identify real-world effects and benefits.

The first version of the handbook was created by the European support action FESTA (Field opErational teSt supporT Action, 2007–2008). The handbook has since been frequently updated by the FOT-Net community and follow-up coordination and support actions CARTRE and ARCADE.

The handbook gives practical advice on how to set-up and conduct FOTs and how to analyse the results. It provides and advocates a systematic research-oriented approach. The FESTA methodology is summarised in the so-called FESTA V in Figure 1.

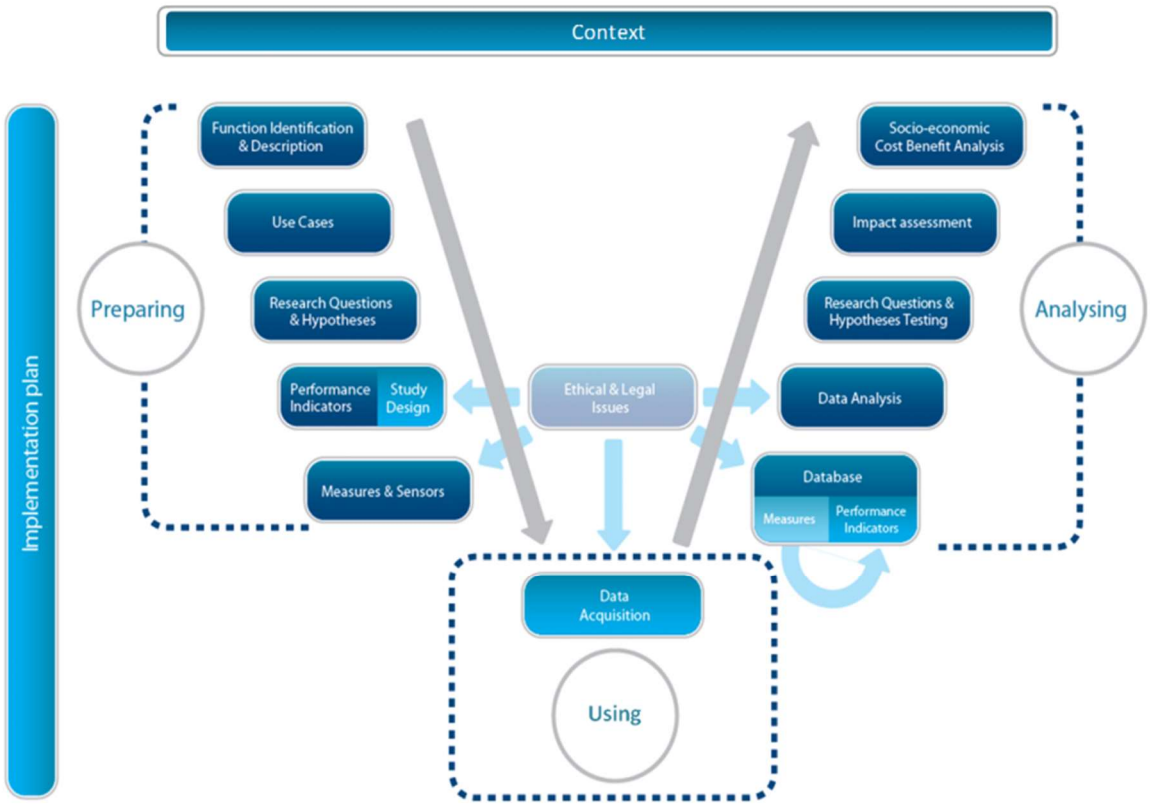

Figure 1: The FESTA V

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PREPARING: The steps on the left side of the FESTA V highlight that research should start from understanding the tested systems and defining the main research questions. Commonly agreed priority research questions and test plans & methods are key for efficient collaboration between partners. It pays off to clarify goals and get the team committed.

Research questions lead to related data needs and performance indicators, and how to collect such evidence.

USING: Managing vehicle fleets and recruiting test subjects in order to collect data is a feat in itself. Data should be free of major errors and well documented to support analysis by several persons. In addition, one has to ensure the safety and privacy of test subjects and maintain confidentiality regarding the trade secrets of the tested products. Before the tests can truly begin, a phase of pre-testing (piloting) is required to make sure that everything will run correctly and smoothly.

ANALYSING: Measurement data, observations and interviews are used to conclude on the research questions and hypotheses. Effects identified in the tests are considered also from wider societal/stakeholder perspectives. The findings are to be scaled up: what would change, if the tested new system or service gains popularity. Finally, a cost–benefit analysis can clarify the monetary value of identified benefits versus costs.

2.2. The need for a common methodology

A common methodology adopted by projects has major advantages, allowing for comparison of results between FOTs, providing a common vocabulary, and enhancing communication between stakeholders involved in FOTs. The FESTA methodology is not a rigid one; it is adaptable and kept alive by exchanging experiences and lessons-learned from projects using the methodology. For automation studies a common methodology is important, as stakeholders are not only interested in the findings of individual projects, but in gaining knowledge about the wider impacts automation may have.

The FESTA methodology puts a strong emphasis on defining research questions and hypotheses, inspired by the traditional impact areas of vehicle ICT: safety, mobility, environment and efficiency. With new functions enabling new mobility concepts and services, impact areas become wider (e.g. land use). Covering them requires considering multiple research questions of interest for stakeholders.

In the coming years, new methods will be developed to evaluate different aspects of CCAM. This document may function as a concise overview of the FESTA methodology, allowing perceiving easily what general elements and guidelines of FESTA are useful and where innovation and new methods are needed.

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3. Micro-FESTA

The FESTA handbook in which the methodology is described in detail consists of some 200 pages. As the methodology was developed for large-scale FOTs, this is probably far too much detail for beginners to start from in small projects. However, there is a lot of practical information in the handbook that is useful, when reaching certain steps in a project. The handbook includes the FOT Implementation Plan (FOTIP), which serves as a practical checklist. It highlights the main activities and tasks that would normally be undertaken in successfully completing the project and raises awareness of critical issues.

The Micro-FESTA approach uses the three main phases of the FESTA V and discusses their use in pilot projects:

1. Preparing:
   - Defining the pilot: Defining functions, use cases, research questions and hypotheses
   - Preparing the pilot: Determining performance indicators, study design, measures and sensors, and recruiting participants
2. Using:
   - Conducting the pilot: Collecting data
3. Analysing:
   - Analysing the data: Storing and processing the data, analysing the data, answering research questions
   - Determining the impact: Impact assessment and deployment scenarios, socio-economic cost–benefit analysis

3.1. Preparing

Defining the pilot: Defining functions, use cases, research questions

In the first step, the pilot is defined. The main questions to address are what will be evaluated and how will that be done? The following sub-steps can be distinguished:

a. Selecting the **functions** to be tested: define whether some (automated) functions are tested, or the functioning of whole vehicle and/or automated service.
b. Defining the connected **use cases** and **situations** to test these functions in: define in which conditions and situations the vehicle is driving automated.
c. Identifying the **research questions**: what are the questions the pilot should answer. Defining research questions is usually a difficult and iterative process, as many questions around automation can be posed, but not all questions can be addressed by a single pilot. Stakeholder involvement is crucial in prioritization: what kind of questions do they think are of highest priority? Research questions are closely related to the impact areas the pilot is interested in, such as safety, mobility, efficiency, environment, business models and technical functioning. Industrial projects may highlight changes in work practices and processes instead of traffic efficiency. Projects should have a clear focus to guide the work and get the team and stakeholders committed.

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Preparing the pilot: Determining performance indicators, study design, measures and sensors, and recruiting participants

In this step the pilot is prepared. The main question is how can the pilot be set-up in order to be able to answer the research questions? It is often necessary to go back to considering the research questions. The following sub-steps can be distinguished:

a. Defining **performance indicators and measures**: define what indicators are to be used for answering the research questions and how to measure them. For example, a performance indicator could be a high degree of user acceptance as measured with a technology acceptance questionnaire. Examples of performance indicators are widely available in impact assessment publications and FESTA.
b. Defining the **study design**, or in other words, the **procedures** to be followed: determine the practicalities of the pilot, where will the pilot take place, for how long, who is to be involved. The "how long" and "how many" should be considered from data needs perspective, together with step a), to reach sufficient data for analysis. Ethical and legal aspects need to be taken into consideration: such as safety, privacy and good research practices. If permits will be needed, be aware that seeking them may take a long time.
c. Defining **tools and sensors**: what kind of tools and sensors need to be used for measurements? These could for example be sensors in the vehicle collecting data about the driving performance, video to study the interaction with other road users, or qualitative instruments such as user questionnaires. For small studies it is important to determine what data can be collected within the limited resources available, preferably using existing products.
d. Defining and recruiting the **participants**: who are the users to be involved in the pilot? Recruitment is no minor task, especially if the sample of users should be balanced or a specific target group (e.g. families) is sought for. A consent form must be prepared for the participants in order to agree on use of personal data and on safety precautions. It is recommended to use existing templates and checklists, but legal advice will usually be required to finalize forms. Still, the main parts of the contracts should be kept brief and easily readable.

3.2. Using

Conducting the pilot: Collecting data

When the pilot design is completed, data can be collected according to the plan. The following sub-steps can be distinguished:

a. **Pre-test all procedures**: even with the most carefully defined pilot, unseen difficulties may arise. Trying out the pilot in real-life conditions is essential to find out what works and where improvements need to be made. Proper pre-testing ensures that everything is ready for performing the pilot. Especially when testing prototype systems and services, fine-tuning the user experience and system setup & stability could last several months, as this may be the first attempt at long-time operations. It is good to be critical during trials, as bad user experience is nobody's goal. During pre-tests, data

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management and evaluation methods should also be tested: example calculations should be made to ensure that the collected data can yield results.

b. **Perform the test(s), collect data**: the test procedures are now executed according to the plan with real users. Keep a log on what happened during the pilot and the problems encountered: anything that may affect data analysis later. Examples are extreme weather or traffic conditions, or break-down of the systems. Version changes of the tested system are important to document as well. Large changes to the tested systems should be avoided during the main tests to avoid unnecessary difficulties in data analysis later, when making comparisons.

3.3. Analysing

Analysing the data: Storing and processing the data, analysing the data, answering research questions

The collected dataset is analysed in order to be able to answer the research questions. The following sub-steps can be distinguished:

a. **Storing and managing** the data: data needs to be stored in a safe and secure way, taking into account data protection and privacy regulations. Even in small projects the datasets can grow large and several organisations may be involved. It is recommended to consider data management aspects right from the project start: potential use of cloud services, need for agreements, access rights etc. The format of data logs should be considered from the viewpoint of available evaluation tools that could make the work easier and analyses more comprehensive.
b. **Documenting** the data: it is important that sufficient details of the data and its post-processing steps are documented for use later on and by other persons than the ones who collected the data.
c. **Calculating indicators:** With CCAM, the datasets can be large and complex to process. Software for calculating required indicators from log files may need to be customised. Automated vehicles may have logging features that provide information about the situation (e.g. detecting pedestrians) that simply data processing. Large publicly funded research projects make some of their tools and data formats available, they are worth considering.
d. **Analysing** the data: depending on the type of data and the questions to be answered the data needs to be analysed using statistical and/or descriptive methods. This may be work for a specialist.
e. **Answering the research questions and presenting the results**: the data analysis will provide answers to the research questions posed, and need to be presented in a way that is comprehensible for non-experts, specifically the stakeholders.

Determining the impact: Impact assessment and deployment scenarios, socio-economic cost–benefit analysis

The last phase is determining the wider impacts of the pilot and how the results could be used for developing business models or value cases. It builds on clear data analysis results: identified changes, benefits and drawbacks. The following steps can be distinguished:

a. **Scaling up** the results: determine what the results mean for a wider use of the system or service in other areas. This assessment commonly requires detailed statistical data

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(e.g. accident data, performance numbers) regarding the current state of things. The wider impacts of previously identified effects can be extrapolated using various models and methods: at least by using simulations, mathematical models of impact mechanisms (a change in something leads to changes elsewhere, as proven by previous studies), future scenario analyses (various options can be considered, e.g. target years, fleet penetration rates, regulation support) and snapshot approaches (what would change, if the system would instantly be taken in use). Regardless of the chosen method, it is important that the logical steps and assumptions used in scaling up are kept transparent for the audience. Even to the level that the assumptions or used factors could be later revisited, if better estimates become available.

b. **Cost–benefit** analysis: compare the costs and benefits of deploying the service. These could be measured in monetary terms but also in qualitative terms.
c. Performing **stakeholder analysis**: define who will potentially profit from the deployment of the system and what the benefits are for this group. Consider roles of different stakeholders. Stakeholders may come from public authorities, industry (manufacturers and service providers) and end users. It may be useful to organise workshops with stakeholders, presenting and discussing the results and potential impacts and benefits. This step is important at the end of the project for deployment purposes, but stakeholder involvement is also needed at the beginning and during the project to ensure buy-in from stakeholders.
d. Developing **business and deployment models**: together with stakeholders it needs to be determined how the system or service can deployed in the future, who will have to invest to realise wider use or bringing the system or service to market. Consider actions to be taken by the stakeholders and develop future roadmaps.

3.4. Making the data and results available for others

In order to be able to contribute to a bigger picture about the impact of road automation the following recommendations should be taken into consideration:

- **Sharing data**: make data available for further research, ensuring that this data is anonymized and non-confidential. Seek for win-win collaboration, for example with academic partners, to get more analysis results from the same dataset.
- **Document** the study design, the data collection process, the data and the results in such a way that others can understand what was done and are able to re-use this information. It is also beneficial to document the main lessons from organising the tests and recommendations for future similar projects.
- **Publicise** the results and main documents for a wider audience. It is the role of pilots and FOTs to provide first concrete results from using new technology and discuss the steps to be taken before full deployment.

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4. Additional recommendations from and for small CCAM pilot projects

There are lessons to be learned from the pilot projects carried out in recent years. In this section we give a short list of recommendations that may be useful for new projects. Three types of recommendations can be distinguished, related to (i) setting the goals in the beginning of the project, (ii) defining and performing the tests, and (iii) sharing the results with others.

4.1. Goals

- Set clear goals for the pilot and clarify the roles of partners.
- Find a good balance between technology development and identifying societal/industrial benefits.
- Gather information on the systems and functions to be piloted also from evaluation and user testing perspectives, e.g. which accident types and operations they might impact. Be clear about the technology matureness and practical readiness.

4.2. The tests and analysis

- Consider the role of infrastructure and links to other systems: connected and automated systems often require support from other systems or some changes to digital or physical infrastructure to reach their true potential, e.g. higher speed and efficiency.
- Define a limited set of explicit research questions. Focus on practicality, but keep in mind that with a relatively small additional effort, sometimes more can be measured.
- Discuss the role of baseline data: if one wishes to identify how automation changed the situation or operations, there needs to be plenty of data of how things were before. Most experiments are about before–after, without or with, function off or on. However, sometimes there is simply no baseline.
- Start thinking from the beginning about whether and how results can be scaled-up. What kind of data is available for the work, what methods could be used?
- Consider, whether results can be used in simulation and/or traffic models, in order to facilitate scaling-up. Are the existing simulation models detailed enough and what would be the role of simulations, how much effort would be required?
- Documentation in all stages is key to obtain results that are useful for the future.

4.3. Sharing

- Multi-stakeholder representation is usually needed. Develop a communication strategy with stakeholders and the general public.
- When working with private partners, some data, results and methods can be shared, but not all. Pushing for collaboration often improves the project results, even if non-disclosure agreements are needed, but beware that these may take some time to establish.
- Learn from other projects and consult evaluation experts. The European Knowledge Base for Connected and Automated Driving is a good starting point: https://www.connectedautomateddriving.eu/

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