Towards an ‘agile’ common evaluation methodology for C-ITS

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Abstract

The FESTA evaluation methodology for ITS possesses limitations, with few feedbacks, limited opportunity for corrective actions, and a tendency towards the prescriptive. In this paper, the need for a more ‘agile’ approach to evaluation is explained, specifically for Cooperative ITS (C-ITS). 14 C-ITS schemes funded by the UK’s Department for Transport (DfT) are introduced, with the aim to devise a new methodology and apply it to a carefully identified selection. The intention is to generate discourse and ultimately produce a fit-for-purpose common evaluation methodology (CEM) transferable to subsequent future schemes, and mitigating some of the pitfalls of FESTA. The new approach would, moreover, enable local conditions and criteria to be evaluated in such a way as to yield more accurate impact assessments and targeted capital spend for the deploying organization, ensuring greater accountability and value for money for deploying organizations and funding bodies.

Keywords:
EVALUATION, AGILE, COOPERATIVE ITS

Statement of the problem

Existing approaches to evaluation of ITS and C-ITS, such as FESTA, are potentially flawed. There are too few feedbacks, the process, as commonly used, tends towards the linear, and is thus too prescriptive and not sufficiently agile. In some circumstances, therefore, the evaluation may not be suitably focused, may ask the wrong research questions (RQ), work with the wrong performance indicators (PI), and crucially, may not permit corrective actions. At the same time, there is an increasing desire to move away from prescriptive methodologies towards something user-led, for example by cities deploying ITS/C-ITS. Such an approach would mitigate the weaknesses of attempting large-scale evaluation and provide more tailored results or impact assessments, benefitting the deploying organization in terms of achieving policy objectives and value-for-money on its investment.

In the light of this, the authors propose a new approach to evaluation of C-ITS, retaining common
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elements that are applicable to multiple schemes, whilst at the same time enabling users to benefit from a tailored methodology – an ‘agile’ Common Evaluation Methodology (CEM) for C-ITS. Benefits for those seeking to deploy C-ITS include accurate step-by-step evaluation with the ability to feedback to previous steps, better assessment of components of a scheme, more flexible approaches to deployment, and more accurate, targeted investment decisions, reducing financial wastage. This will have the added benefit for funding bodies, who will be able to guarantee their money is being spent optimally.

Existing approaches to ITS / C-ITS evaluation

The evaluation process for C-ITS projects in Europe is based on the FESTA methodology (FOT-NET, 2015), drawing on the experiences of other cooperative systems projects including FREILOT, Drive C2X and COSMO. FESTA is based on the study of the behavior of users in different use cases against their behavior during the baseline operation before C-ITS services are activated. Use cases are created to understand local variations of each service. Research questions and hypotheses are defined, to be studied using performance indicators. These are quantitative or qualitative measurements, agreed beforehand. The derivation of indicators influences the data collection requirements.

A direct analogy to this method of work can be found in the ‘Waterfall’ model of software/engineering design (Bell et al, 1976). In the Waterfall model, the development/production stages are initiated in a sequential manner, and each stage will typically be completed before the next stage is started.

In a similar fashion, each stage within the FESTA methodology, as it is normally used, is largely completed before the next stage begins (see Figure 1).

![Diagram of FESTA methodology](image)

**Figure 1 – The FESTA methodology is approximated here**

There are benefits to this method of assessment, as it allows for more detailed future planning and for the allocation of resources in advance. For large real world deployments, it is absolutely necessary that there is a firm plan of work for the deployment of physical assets, but there is no need for the same rigidity of process in either the planning or initial analysis stage. In the C-ITS context, for example, it
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costs a lot of money and time to re-equip a fleet of vehicles with data loggers. However, lack of flexibility can lead to mistakes in the initial project preparation, and this can propagate through the system.

Further compounding this is the use of milestones and deliverables (which are prevalent within European Funding requirements). The use of deliverables, whilst valuable for assessing progress and providing mid-project content, also serves to set all work done, up to that date, in stone. This can form a prescriptive set of requirements which must then be applied throughout the rest of the project evaluation. Furthermore, providing these deliverables, especially if they are in the form of extensive documents rather than working prototypes/analysis tools, can take valuable time away from the assessment teams at a point in the project where the focus should be on achieving the deployment of the physical assets and the supporting data analysis framework.

It should be noted that the FESTA methodology is not strictly linear. Within the FESTA handbook explicit mention is made of the need to iterate certain steps. However, by not showing the explicit iteration and feedback steps, the FESTA methodology gives the impression of a purely linear process, an impression that is borne out by the implementation of this assessment methodology.

It is proposed that these flaws in the FESTA system (and the wider issues of large scale funded projects) can be overcome through the use of a more flexible development methodology. Specifically, this will be through the adoption of more ‘agile’ approaches in the initial development stage, up to the point where it becomes impossible to do so any longer.

Agile methodologies, in this context, will take the form of rapid iteration and early delivery of the components needed for the field operational test (FOT), including the back-end infrastructure needed for data storage, the research questions/hypothesis to be answered, and the analysis platform/questions to be used. Through the use of test data (data from simulations or other projects), it will be possible to test all stages of the FOT barring the actual deployment of the physical assets.

Through this, it will be established if the research questions, hypotheses and performance indicators are fit for purpose.

**Overview of UK schemes**

At this point the authors introduce 14 C-ITS schemes funded by the UK’s Department for Transport (DfT). As can be seen from the following table, the schemes are very diverse; they are specific to the deploying organizations’ (cities or counties) policy objectives, stakeholders, traffic conditions, road networks and spatial characteristics. A selection of these schemes underpins the new approach to evaluation.

<table>
<thead>
<tr>
<th>Cities</th>
<th>Details</th>
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<tbody>
<tr>
<td>Blackpool</td>
<td><strong>Blackpool tourism traffic flow and enhanced car parking guidance program</strong></td>
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<tr>
<td></td>
<td>The program will achieve the following:</td>
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<td></td>
<td>• Providing in-car traffic information and car parking guidance using smartphone app or</td>
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<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
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<tbody>
<tr>
<td>Derbyshire</td>
<td><strong>Pre-emptive traffic management</strong>&lt;br&gt;Developing a prototype system that utilizes 3rd Party floating vehicle data analytics to trigger traffic management interventions to:&lt;br&gt;• Prevent build-up of traffic congestion on the local network&lt;br&gt;• Generate traffic management information that influences the flow of traffic through the network&lt;br&gt;Information generated by the system will be available for display in-vehicle, via a mobile app, and on mobile roadside variable message signs (VMS)</td>
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<tr>
<td>Dorset</td>
<td><strong>A31 Smart Collaboration</strong>&lt;br&gt;This scheme develops a prior congestion warning for road users accessing the A31/Ferndown area. The aim is to provide a step change in network management through improved monitoring and the real-time dissemination of information to road users, including freight vehicles. A connected approach will provide users with knowledge from which to make informed decisions on preferred routes and help balance traffic flows and prevent further congestion</td>
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<td>Middlesex University and Kings College London</td>
<td><strong>Central London Testbed Project</strong>&lt;br&gt;A university collaboration building a Federated Connected Vehicle Testbed System (FCVTS) to explore the development of C-ITS by building two testbeds and using data from the testbeds to investigate the building of applications for the Connected Vehicle environment using VANET/G5 technology as well as emerging 5G mobile networks</td>
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<td>Newcastle</td>
<td><strong>C-ITS Smart Corridor Newcastle</strong>&lt;br&gt;Building on existing deployments from the Compass4D project (Hill and Edwards, 2016), this scheme tests roadside and on board equipment and personal devices in order to make vulnerable road users safer and reduce the environmental impacts of congestion and idling at traffic lights</td>
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<tr>
<td>Peterborough</td>
<td><strong>Connecting Peterborough</strong>&lt;br&gt;Utilizing newly emerging digital technology, this scheme provides real time, two-way, journey information directly to visually impaired users, allowing easier access around Peterborough city center</td>
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<td>Portsmouth</td>
<td><strong>C-ITS Platform Project</strong>&lt;br&gt;Creating an on street test environment within Portsmouth to prove the viability of available communication technology to provide additional ‘real time’ information on how the road network is performing, but also to give support to road users to enhance their journey experience and improve road safety</td>
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<table>
<thead>
<tr>
<th>Location</th>
<th>Scheme Description</th>
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<tr>
<td>Somerset</td>
<td><strong>Hinkley Point Energy Efficient Intersections (EEI)</strong>&lt;br&gt;Hinkley Point C (nuclear facility) is one of the largest construction projects in Europe. Up to 750 HGV movements are expected every day in addition to approximately 5,600 construction worker movements from park and ride facilities via designated routes to the work site. Repeatability and journey frequency presents a unique opportunity to evaluate Signal Phase and Timing (SPAT) technology, where construction traffic estimates suggest up to 3 million vehicle kilometers will be travelled, with 615,000 intersections crossed. This EEI scheme aims to reduce the impact of these vehicle movements through more efficient control of vehicle start/stop cycles, by enhancing existing traffic signals and deploying Connected Intelligent Transport Systems technology in HGVs and PSVs.</td>
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<td>Southampton</td>
<td><strong>Better Journeys in Southampton—Bluetooth</strong>&lt;br&gt;A city-wide demonstration of how a C-ITS implementation collecting Bluetooth data on a MESH network on ten corridors can be dynamically utilized to inform and manage traffic in Southampton. This data will provide real time travel information and junction control to influence people’s travel choices, respond to incidents and improve air quality.</td>
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<tr>
<td>Swindon</td>
<td><strong>Connecting Swindon</strong>&lt;br&gt;A scheme to improve network and traffic management capability utilizing real time traffic information aiming to reduce the impact of traffic congestion on road users and businesses by getting real time information to them more quickly, and testing new technology platforms in real life conditions to enable technology partners to further develop the technology in the future.</td>
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<td>Warrington</td>
<td><strong>Warrington Integrated Transport System (WITS)</strong>&lt;br&gt;The aim is to create a ‘smart travel city’ to support economic growth, reduce delays and improve air quality. It will combine real time journey information and smart technology to develop network strategies to manage traffic more proactively. The developing system will also provide real time information to businesses and the general public via on-street information displays, interactive webpages, social media and an innovative local mobile phone application for drivers.</td>
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<td>West Midlands</td>
<td><strong>West Midlands Green Light Optimal Speed Advisory (GLOSA)</strong>&lt;br&gt;The scheme will provide drivers with speed advice that allows them to pass traffic lights during the green phase. Where this is not possible, a Time to Green (TTG) function provides a countdown for stopped vehicles, showing when the traffic lights will turn green. The project will test GLOSA using freight vehicles, as they stand to gain the most from reduced stop-start, particularly in terms of fuel use.</td>
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<tr>
<td>Worcestershire</td>
<td><strong>Automated Incident Management</strong>&lt;br&gt;A system providing time and location stamped critical issue communications between partner control centers and on-highway incident management staff. The system will have multi partner access to allow highway incidents to be dealt with in a coordinated and</td>
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seamless way. On-highway staff will be able to directly update the system from site. The system can be viewed through interactive large screen displays with additional applications covering data feeds from traffic flow monitors, cameras, street works, road closures, highways maintenance, environmental conditions, intelligent traffic signal control, VMS (mobile and static) local and national traffic and travel updates.

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<th>York</th>
<th>Eboracum</th>
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<td>Eboracum aims to improve junctions on the A59 corridor in York in line with local policy objectives using vehicle data instead of fixed roadside technology</td>
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Table 1 – C-ITS schemes funded by the UK’s DfT

Three DfT-organised Road Technology Operators Group (RTOG) events per year facilitate dissemination and outreach of these schemes, and are also open to other stakeholders connected to UK C-ITS development and deployment. Each scheme is also allocated to one of four C-ITS working groups (SPAT1, Asset Management, Smarter Parking and CIT2), whichever is most appropriate to the focus of a scheme; these working groups also meet independently of the main RTOG events.

Roadmap towards an agile CEM

In developing an agile approach to a common evaluation methodology, there are several key challenges which must be considered. These will be elaborated in the final paper and presentation.

Developing the assessment methodology based on previous, present and future C-ITS projects

The first step in the development of a new assessment methodology will be to ensure that it would be compatible with existing C-ITS projects. Any assessment scheme with unrealistic requirements would not be deployable in the real world and thus, regardless of methodological desirability, not usable. Compatibility would be tested through examining previous research projects and looking for those points in the project time-frame where a greater period of iteration would lead to an improved project outcome. In addition, points at which no further iteration is possible would also be identified. This would allow for the transition between the agile methodologies of early development and prototype towards the more traditional on-street deployment phase.

Criteria for selecting suitable schemes to evaluate

The second challenge is to analyze the 14 schemes to identify which are suitable for trialing a new evaluation approach. This may depend at least in part on what each deploying organization wants to evaluate. Whilst the main aim of this paper is to initiate a new approach to a common evaluation methodology, the schemes presented in this paper are very diverse, and all have locally-specific criteria (such as objectives, services, desired impacts, stakeholders, technology, data collection

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1 Signal Phase and Timing
2 Connected Intelligent Technology
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methods, etc.) that inevitably influence the evaluation methodology. Enabling a tailored impact analysis for each deploying organization (i.e. one that is user-led) is desirable, but represents an additional challenge to the developer of a common evaluation framework.

Services versus bundles
A challenging aspect of evaluation is how to evaluate C-ITS services on an individual basis, or as part of a service bundle, and whether it is possible to evaluate the bundle as a whole. Key considerations include: how is each service weighted in a bundle? How do we evaluate a deployed service against a baseline? How do we evaluate whether an effect is attributable to a deployed service or due to some other reason? These are crucial questions in ensuring the efficacy of any evaluation.

Data quality and quantity (collection and processing)
Fundamental to any evaluation is the question of data collection. How do we ensure that data is collected in a consistent, comparable way, and in the required amount to enable appropriate analysis to take place, i.e. data quality and quantity?

Modelling and micro-simulation
Micro-simulation and modelling underpin many evaluations, but must complement, not replace, real data collection and analysis. What is the role of modelling and micro-simulation? How do we make full use of the tools whilst not becoming overly dependent on them?

Avoiding common pitfalls
The Compass4D project (EC, 2013-16) (Hill and Edwards, 2016) produced a set of ‘lessons learned’ from its FESTA-based evaluation. Some or all of these must be taken into consideration when devising any new approach to evaluation, in particular three which should be addressed with an agile approach:

- Identify the methodological areas which work and how they can be applied in future
- More detailed work on the underlying conceptual framework behind research questions
- Identify tools which can be generalized for use in other projects/schemes

Some practical recommendations are also made which should be implemented by any scheme:

- Data analysis personnel should be involved from early in the project and should lead the specification of data format
- Quality assessment tools should be developed early with a strict procedure to be followed in the event of problems

Approach for developing an agile CEM

This section outlines the authors’ approach to developing an agile common evaluation methodology.

Task 1 Information Gathering
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There is extensive literature already available on evaluation schema, however a lot of this is available in multiple different formats including government produced documents on evaluation (Web_TAG) or outputs from projects specifically designed to tackle evaluation (FESTA). In addition, there will be extensive documentation on project evaluation from existing projects, which has perhaps not been formalized but which will still offer valuable insights. The first task will be to gather all this information together and start to identify key themes (both present and gaps) amongst the evaluation schemes.

In addition to gathering information from literature sources, information will also be collected from interviews and face-face meetings with the existing DfT C-ITS projects and also from the working groups.

Task 2 Evaluation Creation
The next task is to construct a framework for evaluation. Initially, this will consist of a series of procedures, instructions and potential pitfalls (plus solutions) for running an evaluation. The evaluation framework will exist in this looser (and more flexible) format until there is a finalized version. Previous experience has shown that producing a large, static document as an intermediary point within a project leads to a premature “finalization” of the goals of the project.

Task 3 Evaluation Review and Refinement
Once the draft evaluation is complete there will begin a process of review and refinement. It is not expected that the first draft for the evaluation framework will be suitable for all (or indeed most) of the C-ITS projects, however, there now exists a body of work with which the framework may be compared and tested on selected schemes. If the framework would not have been suitable for historic C-ITS projects then it is likely that it would not be suitable for future projects.

By comparing our framework to previous projects, and detailing how the evaluation might have worked or failed, we can identify key sticking points and alter the framework accordingly. This will be an iterative process which will lead to a framework that is neither too prescriptive nor proscriptive and will be applicable across multiple different projects.

Task 4 Dissemination of Results
The final step is begin the process of dissemination. This will take place through two main work strands:

1) Academic Research. There is currently a dearth of research papers on evaluation, particularly on evaluation within C-ITS for field operational trials. Through publishing 1-2 papers on C-ITS evaluation the authors hope to contribute significantly towards the state of the art in this subject.
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2) “Real World” Dissemination. Even the most cited paper is unlikely to be read by a member of local government responsible for the local implementation of a C-ITS project, and the evaluation of that project. Hence it will be necessary to ensure that the work here is effectively disseminated. This is likely to be in the form of talks at appropriate conferences/workshops (including the RTOG meetings and working group meetings), through the production of appropriate (and non-pay-walled) literature, word of mouth and through face-to-face meetings. Eventually, it is hoped that a critical mass would be reached where knowledge of the importance of effective evaluation is such that interested parties would seek out the information.

Conclusion
A case is developed in this paper for a new approach to evaluation for C-ITS projects. The limitations of existing approaches, such as FESTA, are presented, and an ‘agile’ approach is proposed. The aim of the full paper and presentation will be to produce a prototype agile common evaluation framework for C-ITS applied to a selection of the 14 schemes funded by the DfT, and introduced above.

It is intended that this will generate discourse with the aim to produce a fit-for-purpose common evaluation methodology which is transferable to subsequent future schemes. At the same time, the CEM would also enable local conditions and criteria to be evaluated in such a way as to yield accurate impact assessments and targeted capital spend for the deploying organization, ensuring greater accountability and value for money for both the deploying organization and the funding body.
References