ITS COOPERATIVE SERVICES AND HUMAN FACTORS – THE FOTSIS PROJECT EXPERIENCE

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ABSTRACT: Arial 10 – Justified – Margin 2.5

With the continuous development in the fields of sensors, advanced data processing and communications, road transport oriented applications and services have reached a significant maturity. The EC has been very active in promoting solutions which improve road safety, traffic efficiency and environmental sustainability. As the focus on these solutions shifts from the purely technological challenge to the actual deployment, there is an increasing need to evaluate the impact of the proposed services on the drivers and the services' users in general. In this paper, the experience of the FOTsis project in this area is presented, describing how human factors have been a cornerstone of the project from the design of the different services, which involve intelligent vehicle technologies, to the proposal of the evaluation methodology that will be used to assess their impact. The differences between the FOTsis project and other initiatives are highlighted.

1 INTRODUCTION

In the last decades, several initiatives have had a profound impact on the way road traffic and road safety is managed. The European Commission has been always very active in its activities towards the improvement of aspects of road safety, road mobility efficiency and transport sustainability. Their activities include the directing of efforts of all the relevant stakeholders or the promotion of direct R&D initiatives on the topic. Projects like CVIS took the first steps towards using advanced communications and sensors to support the drivers in their routine tasks, steps which have, through the years, lead the way to the current generation of Cooperative Services, exploiting the full concept of providing a complex data exchange framework between all the entities involved in the road environment.

Even though the foundation of the Cooperative Services is arguably the underlying communications architecture [9], as the prime technological

enabler of the whole Cooperative framework, Cooperative Services go beyond the communications and the data exchanges between entities to consider advanced data acquisition sub-systems and advanced processing procedures to achieve more ambitious goals towards improving road safety, traffic efficiency and the environmental sustainability in the road transport applications.

However, as technological solutions have become more consolidated, some of the most recent research initiatives in the field of Cooperative Services have been focused not so much on the systems to be deployed, and the technologies to support them, but rather on analysing their actual effectiveness on a set of more particular objectives or goals, or their impact on the driver's behaviour. The way of addressing these issues is still not clear, and different methodologies have been applied to try to successfully collect and analyse the data that would facilitate these tasks.

The FOTsis project is a currently ongoing Cooperative Services FOT (Field Operational Test) project focusing on the infrastructure aspect of the Cooperative ITS environment, which aims to evaluate the impact on the areas of road safety, traffic efficiency and environmental sustainability of 7 close to market applications. These applications or services cover road-safety oriented services as well as road efficiency oriented services, and will be tested in 4 different European countries [5].

In a similar way to other FOT initiatives, FOTsis is addressing the whole testing procedure as established by the reference FESTA project for Cooperative ITS impact assessment [4], but, while the FESTA methodology was designed primarily with vehicle-based systems in mind, the infrastructure-based approach of FOTsis services and applications poses a number of different challenges and it is expected that a significant contribution to the way of evaluating Cooperative ITS can be obtained at the end of the project.

In this paper the particular aspects of analysis of the impact of the FOTsis services on the drivers' behaviour will be described, from the formulation of the initial assessment assumptions to the final analysis methodology, going through the test design issues and the participants' recruitment process.

2 RELATED WORK

The impact on the drivers' behaviour of the Cooperative Services and earlier

initiatives has been explored in different ways. One of the initiatives that proposed in its day –and still being worked on- an overall methodology of testing Cooperative applications in general, and the impact assessment in different areas in particular, was the FESTA project. The project's resulting handbook [4] provides a foundation to support the overall tasks of preparing executing and evaluating Cooperative applications. The FESTA methodology however is not complete, and as new projects face and solve challenges, the FESTA handbook is enriched for future initiatives.

The FESTA methodology proposes two basic evaluation strategies: one based on impact areas, which results in specific measurements to be taken if the evaluation is to be carried out properly. The second strategy is based on the systems under test themselves, and results in a series of testing scenarios that allow for a direct evaluation of the performance of the services. Both strategies have their own limitations and that is the reason why several projects, including FOTsis, have opted instead for a combination of both. Another relevant aspect is the fact that even though the FESTA methodology considers both objective and subjective data collection, the proposed evaluation methodologies rely more heavily on objective data statistical analysis, which may not be sufficient for certain low-occurrence events, such as road accidents, which are critical for road safety assessment [15].

One of the most representative works contributing to the development of the most recent revision of the FESTA methodology was the TeleFOT project [16], a FOT project which investigated the impact of functions brought to the driver and aftermarket devices in vehicles for driver support and raise awareness of their potential [11]. The project built on the general methodology proposed by FESTA and expanded on the particularities of the devices under test, adapting the different stages to those particularities [8]. One of the most interesting contributions of TeleFOT in the field of user behaviour and acceptance was the application of the concept that usability of any device or system depends not only on the device, but also on the context and environment in which it is used [18]. Earlier efforts, such as the CVIS

project [2], initiated the assessment of user acceptance of advanced Cooperative Services and established a specific methodology to evaluate the utility, usability and user acceptability of the services proposed in the project, identifying relevant stakeholders and specifying the appropriate analysis methodology for each of them [12]. Both TeleFOT and CVIS used simulators to analyse the impact of the tested systems on the driver's behaviour, but introduced as well, following the FESTA recommendations, the "naturalistic driving studies", which refer to studies undertaken using unobtrusive observation when driving in a natural setting. Naturalistic studies aim to minimize the impact on the driver of elements foreign to the system under test itself, thus providing more useful information on the devices, but on the other hand require more resources in terms of samples and test duration, together with the related resources for data collection, storage and processing/analysing [3].

3 THE FOTsis PROJECT

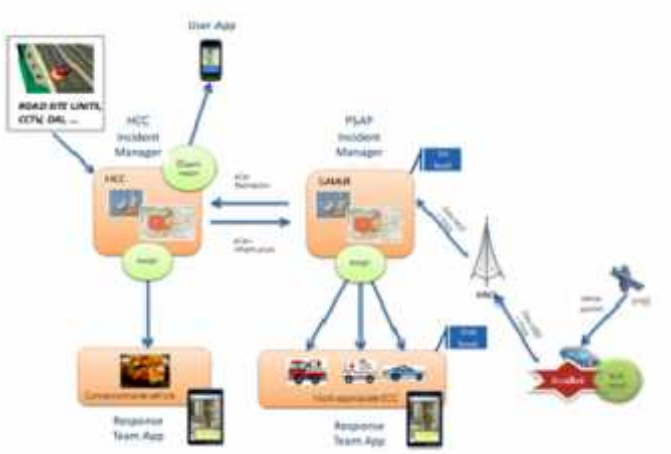
The starting point of the FOTsis project was the realization that a major source of information that may in fact have a significant impact on the drivers' behaviour was not fully utilized in the Cooperative ITS developments: the infrastructure-based data. Based on this data, a number of FOTsis Cooperative Services were proposed as a combination of functions serving a clear goal in terms of proposed impact, whether in road safety, road traffic efficiency or environmental sustainability; being necessary the definition of the particular hypotheses and measurements to carry out the assessment successfully.

Human factors needed to be taken into account too. Infrastructure-based road safety services involve different actors with different requirements and operative routines, from floating emergency teams to emergency coordinators, through road operator traffic managers and road users. The variety of users is a challenge both for the design and the analysis stages, but there was expertise in the FOTsis consortium to confidently address these challenges with the knowledge that the proposed changes would effectively have a positive impact on the operative of the tasks that the services support.

In this paper, analysis will be focused on Service 1/2 – Emergency/Safety Incident Management Service, a particularly complex service, which extends

the standardized e-call concept and that ultimately aims to combine the resources of the emergency response PSAP and the road operator when facing a road incident. The road operator becomes an actively agent in the incident response, being able to receive a call from the driver's application and dispatch its own teams to collect more data about the incident. At the same time, there is a real-time exchange of information between all the involved parties, including notifications to other drivers who may be approaching the area (Fig. 1).

Figure 1. FOTsis integrated Service 1/Service 2 diagrams



The major addition of this service to the current situation is the information about positioning (incident/accident, dispatched teams, overall scenario) and status (response protocol stage acknowledgements, additional incident information) that is exchanged in real time over the system.

3.1 FOTsis services design from human factor perspective

As mentioned in the previous section, one of the main challenges for the FOTsis services has been the variety of users who, sometimes in combination, can be involved in a certain service, and whose needs and requirements had to be taken into account when specifying the service and the analysis methodology for its impact assessment.

There are two aspects in which the design of the services has been taken into account. One is the operative design of the service itself: what is the task flow within the service and who needs to do what and in what order to achieve the expected results. The other is the way the actors of the service interact with the task flow operations.

The second factor is of course related to the Human-Service Interfaces (HSI) [14], critical for the services to work efficiently. The efforts to ensure a higher efficiency of new in-vehicles information services have led to the establishment of European principles and standards for HMI-HSI development at the same time that they resolve the main legal problems that could derive undesirable results of the new services. FOTsis has followed these recommendations in the design of the services with the objective to guarantee that the project results are not affected negatively by a wrong application of the HIS principles.

Therefore, recommendations for the final design of the FOTsis Services 1 and 2 are: (1) Incident reporting/Warning notification will be received in the tablet/mobile phone using a visual and audible signal; (2) Because there is a lot of communication between the control center and the driver, the number of intermediate steps (so that messages) must be reduced until the end of the incident, to avoid driver overload and distraction; (3) No part of the system should obstruct the driver's view of the road scene; (4) The driver should always be able to keep at least one hand on the steering wheel while interacting with the system; (5) The system should have adequate instructions for the driver covering use and relevant aspects of installation and maintenance; (6) System instructions should be in languages or forms designed to be understood by the intended group of drivers; (7) Product information should make it clear if special skills are required to use the system as intended by the manufacturer or if the product is unsuitable for particular users; (8) When driving with passengers, the use of tablet should be left only other passenger.

3.2 FOTsis services impact analysis

FOTsis impact assessment methodology is based on FESTA proposal and practical contributions from other project as TeleFOT, FOTsis particularities have required a special adapted methodology (Fig. 2).

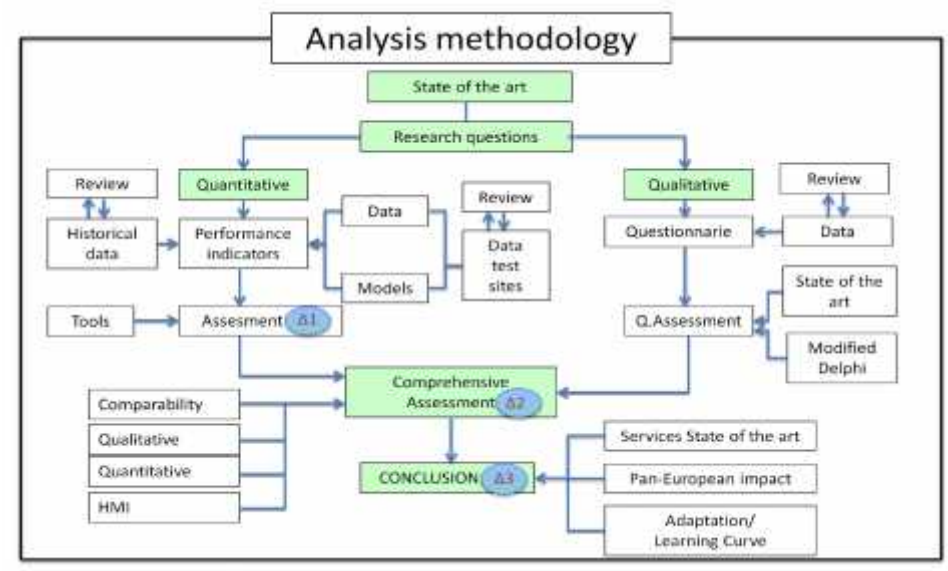


Figure 2. FOTsis proposed Impact Assessment Methodology

1) Preliminary assessment. The FOTsis impact assessment considers separately the quantitative or objective assessment and qualitative or subjective assessment. Quantitative assessment is based on the calculation of performance indicators (PI) from two different data sources: historical data as a reference and the test execution data. After filtering and processing the data, it is possible to estimate Delta 1 as the difference between the reference situation and the execution of the service. The qualitative assessment is based on the calculation of PI obtained from the evaluation of the questionnaires answered by the service users, which must also be filtered and process before they can be used in evaluation. A DELPHI based approach [10] is considered in FOTsis, due to the fact that statistical analysis may distort the results of what can be a reduced number of events on which to base the impact evaluation of the services.

2) In the comprehensive assessment, results from the preliminary assessment are further analysed. Three main aspects are considered in this stage: establishment of a broader reference line in terms of similar European efforts, the integration of qualitative and quantitative analysis results, and the

evaluation of the services' HMI. The final result of the comprehensive assessment is expected to be an overall image on what is the impact of the FOTsis services in the road environment from different points of view, and different reference baselines (Deltas 2 in Fig. 3).

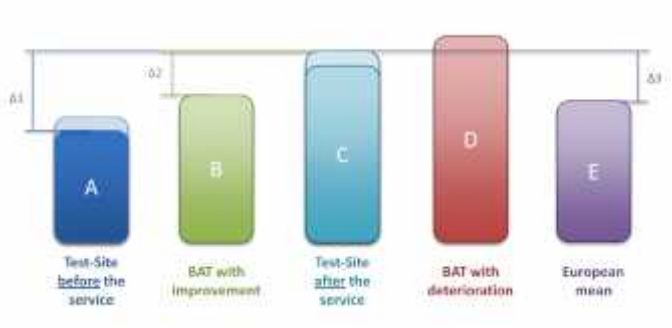


Figure 3. Delta-based comparison diagram of impact of FOTsis Services

There are three major aspects to be taken into account when defining the tests to be undertaken in FOTsis: the participants, the study design and the experimental environment.

For FOTsis Services 1 and 2, the private driver is only one in a group of end-users that include professional drivers, highway and traffic management control centre operators and emergency response dispatch operators amongst others. The number of participants is in this case usually fixed and limited, and moreover, cannot be easily expanded. This focus on a professional target group has also prompted a new approach to the evaluation of the FOTsis services, relying more on subjective information than on statistical procedures as in other FOTs.

According to FESTA methodology, the study design is based on the selected Research Questions and Hypotheses –and the corresponding PI and Measures that will support the analysis of those- as established in the earlier stages of the FOTsis (Example given in Table I).

Finally, FOTsis explicitly includes environmental factors, due basically to the fact that evaluation is decided to be subjectively oriented –which means that it is necessary to gather more details about the circumstances around any relevant event. Another reason is that with 4 different countries involved in the tests –Spain, Portugal, Greece and Germany- regional differences are

considered to make a big difference in terms of Service design, the factors determining the user's acceptance of the service, and the way to evaluate the Services.

Table I. Selected Research Questions & Hypotheses for safety impact assessment

R03 Is there a change in the severity of the accidents?	The severity of accidents and injuries decrease.
R05 Is there a change in the travel time?	The travel time of service users changes.
R14 Is the service uptaken by the service users?	The service is adopted by the users in their daily work/life.
R15 Is there a change of the perceived safety?	Perceived safety increases.
R16 Is there a change in the level of attention?	The level of attention by the user is perceived to have increased.
R20 Is the information provided to the user (HMI/HSI) comprehensible?	The user considers the information of the service to be comprehensible.
R25 Is there a change in the emergency response time?	The time between incident detection and task assignation to the emergency vehicle decreases.
R26 Is there a change in the rescue time?	The response/rescue times decrease.

4 CURRENT STATUS AND DISCUSSION

Given the heterogeneous characteristics of the FOTsis services and the corresponding analysis to be conducted, it is not straightforward to extract a set of common ideas applying to all of them equally. It is clear that traditional statistical methods cannot be applied exclusively in some of the FOTsis services, given that their trigger incidents, the test subjects and the estimated data to be collected will not be enough to obtain significant results. For these cases, FOTsis takes the approach of complementing the statistical analysis with a combination of an expert-based approach and a participant-centred approach to data collection.

4.1 Expert-based approach – FOTsis approach to the DELPHI methodology

Delphi methodology is used in the FOTsis assessment in the preliminary evaluation stage and possibly in subsequent comprehensive assessment stages. The results of the focus group analysis conducted is expected to complement statistical analysis and also to provide significant insight in those cases in which objective data is not sufficient or when subjective data is critical to analyse the impact on the driver's behaviour [10].

As an initial step of this process, a first questionnaire was distributed during the first FOTsis Club meeting among different [1]. The objective of this document was to collect their opinion about certain deployment aspects in relation to the seven FOTsis services which were selected initially for their expected impact in terms of improvement of the mobility efficiency, road safety and environmental sustainability. Valuable feedback from relevant experts on the ITS world was received.

4.2 Subjective data collection

Meaningful subjective data aims to be collected not only from stakeholders but also from test drivers on FOTsis test-sites, giving hints on user preferences, user acceptance, and ease of use and usefulness of the FOTsis Services. This data will be mainly gathered by means of questionnaires that will be distributed to drivers at different stages around FOT execution. Most of the answers will be collected by means of Web-based questionnaires. Personal interviews, when required from impact area leaders, will be carried out to complement that information. Issues involved in the design of a structured questionnaire have been studied by project members, in order to obtain significant results [6]. As a result, a first list of questions is proposed (Table II). It will be distributed to drivers before the FOT execution, which will be used to gather information about the participants' background related to several aspects (experience, educational and social background, technical expertise…) and thus allow the identification of different groups of control. In addition, a number of questions to be formulated to drivers before, during or after their participation in the tests have been enumerated with the objective of compiling all the necessary information for satisfying the Hypothesis in accordance to the corresponding Performance Indicators identified for each FOTsis Service.

4.3 Practical Case

The proposed methodology is described in this section, applied to the FOTsis Service 1 Emergency Management Service and the corresponding activities carried out at the M12 test-site in Madrid, Spain. Service 1 is interesting in the sense that it is a complex service involving different types of users and that it is based on emergency events, which are rare and therefore are not easily analysed with purely statistical methods.

Given the event-based nature of the service, and the involvement of many different actors in the service operations, the test plan specification for the Service 1 aims to collect both objective and subjective data during its execution. Both types of data are critical for evaluation, and special care was taken when designing the questionnaire methodology. Additionally, continuous feedback from the emergency response teams –the key actors in this service- is received in order to address possible areas to be improved to make the service more efficient in terms of its impact on road safety.

Table II. Selected Questionnaire items

WEEKLY	To what degree do you, based on your present knowledge, trust the service to provide you with accurate, real-time information?	1 .. 7
WEEKLY	In case the information provided you with inaccurate information, how did you react?	
FINAL	To what degree do you perceive that the service has provided you with accurate information?	1 .. 7
FINAL	Do you trust the service?	1 .. 7
FINAL	Did you find it difficult to learn how to use the service?	Y/N
WEEKLY	Did you find it difficult to use the service?	1 .. 7
WEEKLY	Do you think your stress level associated with the trip has changed as a result to your access to the service?	1 .. 7
WEEKLY	Did the service make you feel annoyed at any time during the trip?	Y/N

4.4. Preliminary analysis and selected results

The preliminary analysis aims to identify the potential areas in which it is considered that the service will have an impact. The results of this analysis for Service 1 are: It improves the guidance of the emergency teams by retrieval of the position of the incident via in-vehicle GPS and by providing a navigation interface. The ultimate improvement should be in the reduction of the response times; Service 1 improves the quality of the emergency assistance providing several tools which facilitate the exchange of relevant information amongst intervening actors; Service 1 improves resource allocation by means of emergency vehicle real-time tracking at the operations base.

During the full tests execution stage, results of the preliminary analysis have to be complemented with collected objective and subjective data to assess the Research Questions in different impact areas. Currently, the data collection stage is being carried out, and it is not considered that there is enough data at the moment to proceed to a significant impact assessment stage. Nevertheless, a brief overview of the response time of the emergency services is given as an example. The first step is to identify the baseline situation, which in this case is obtained through the SAMUR emergency services agency (Fig. 4). Relevant response times and their evolution are used as the reference against which the service impacts are compared.

In this case, the collected tests times (Table III) yield an average response time of 8:03 min, which is in principle an improvement over the average response time of the SAMUR in the district (SAMUR, 2011), but the large variance of the results will make it necessary a second detailed assessment round to evaluate the circumstances that affected the particular tests.

This is an activity part of the comparability analysis of the comprehensive assessment stage of evaluation, which is part of the planned tasks in the FOTsis project. However, after a first regression analysis as shown in Figure 4 right, it can be anticipated that every minute delay the survival rate increases a 4.7%; or in other words, every 20 seconds saved 1.5 out of 100 people survive**.**

Table III. Service 1 Response Time Collected Data

#	Detection time	Arrival time	Time elapsed
1	13:34:00	13:38:54	0:04:54
2	13:50:00	13:53:25	0:03:25
3	15:56:00	16:01:25	0:05:25
4	13:43:00	13:47:34	0:04:34
5	13:52:00	13:57:14	0:05:14
6	18:00:00	18:15:05	0:15:05
7	13:26:00	13:39:14	0:13:14
8	13:28:00	13:39:36	0:11:36
9	12:41:00	12:45:38	0:04:38
10	12:48:00	12:56:18	0:08:18
11	12:17:00	12:29:09	0:12:09

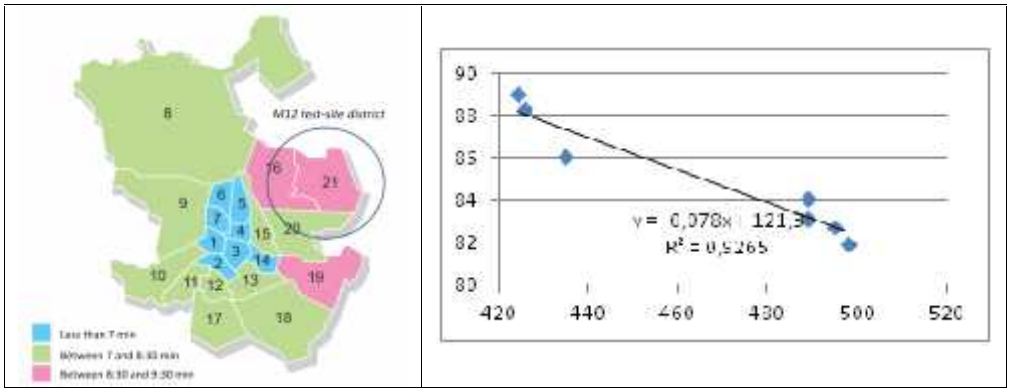


Figure 4. (Left)Emergency response times in Madrid per district. (Source: SAMUR). (Right) Relation between survival rate (%) and response time (in seconds)

5 CONCLUSIONS

In this paper, the FOTsis assessment methodology proposal has been presented. FOTsis services are complex in their interactions with different types of users, and the evaluation of their impact on these users is equally

complex. A first attempt at describing the practical approach of the evaluation methodology in FOTsis has been made using preliminary stages to the Service 1, based on data collected in the tests that have been carried out in the M12, Spain. Due to the fact that only a small number of tests have been conducted, the quantity of data available for analysis is limited at the moment. The description has included all the elements considered relevant for the assessment of the impact of the services, from the recruitment process, to the test design, going through the more theoretical different aspects of the overall FOT impact areas preparation. Special attention has been paid to the subjective data collection, which is considered one of the main differentiating aspects between FOTsis and other similar initiatives. Subjective data collection has to a large extent condition the design of the assessment methodology and as a consequence the data collection procedures in FOTsis. Pending final validation once data from all the services is available, the proposed methodology presents several novel aspects that could be applied to other initiatives addressing similar problems.

Acknowledgments

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