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A CHECKLIST FOR PLANNING AND IMPLEMENTING FIELD OPERATIONAL TESTS OF INTELLIGENT TRANSPORT SYSTEMS

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ABSTRACT

Improved knowledge is needed to understand how drivers use intelligent transport systems, the short- and long-term effects of these systems, and how system performance can be optimized. The Field Operational Test, or FOT, is a powerful evaluation method that can be used to answer these and other questions. Although large-scale FOTs conducted in the past have yielded important knowledge, there is scope for improving the design and implementation of them. In this paper a checklist is presented that outlines the critical steps and considerations involved in successfully planning and implementing a FOT. It derives from work previously undertaken in the European Commission (EC)-funded FESTA (Field opErational teSt support Action) project.

KEYWORDS

Field Operational Test, Intelligent Transport Systems, Information and Communication Technology, Advanced Driver Assistance Systems, FESTA

INTRODUCTION

Intelligent Transport System (ITS) technologies intended to enhance safety, efficiency, comfort/convenience and reduce the environmental impact of the road transport system have been become increasingly common during the last 20 years. In Europe, the European Commission (EC) has taken a lead in funding research that has supported their development and has encouraged EU member states to implement those systems that have been found to be effective. Similar activity has taken place in the US, Japan and Australia. However, to date the emphasis of this research has been on technology development rather than on system implementation and evaluation [2]. The demonstration and evaluation projects that have been conducted have tended to be of limited scale within semi-controlled conditions. As a consequence the results have generally been regarded as indicative. It has not been clearly established that the proposed systems will bring general benefits to a wide range of users, at the societal level, in the diverse traffic conditions that are found in a regional context.

In contrast, the Field Operational Test (FOT) is a powerful evaluation method that can provide a rigorous assessment of ITS-based systems in their intended environment by their intended users, on a scale, and over a time period, large enough for statistically robust data to be derived [1]. FOTs can be designed to address many issues: to

evaluate system effectiveness in providing safer, cleaner and more efficient transport; to assess driver behaviour and user acceptance of systems; to estimate system impact at the societal level, with higher rates of system penetration; to improve awareness of ITS potential; to enhance market acceptance and stimulate demand; and to derive data optimise system design and re-design [1, 2]. The data collected in an FOT can support a wide range of post-hoc investigations by researchers [1].

The first FOTs were undertaken in the late 1990s, primarily in the USA. Important examples, noted by Regan and Richardson [1], include the pioneering University of Michigan Transportation research Institute (UMTRI) assessment of the impact of intelligent cruise control (ICC) usage on passenger car drivers and a subsequent evaluation of autonomous collision avoidance systems (ACAS) in conjunction with General Motors. In both cases volunteer drivers drove vehicles equipped with test systems and data logging equipment for extended periods in normal traffic conditions. These initial FOTs were extended via the US Department of Transport's (DoT's) Intelligent Vehicle Initiative (IVI), which was a programme of FOTs undertaken with truck manufacturers, their suppliers and the haulage industry. The aim was to assess the safety benefits of a range of intelligent vehicle safety systems (IVSS). The programme assessed the effects of collision warning, lane departure warning, intelligent braking, ACC and roll stability warning systems within a strong cost benefit analysis methodology.

Large-scale FOTs have also been undertaken in Europe, notably in Sweden, France, the Netherlands and the UK (see [1] for further detail). The then Swedish National Road Authority (SNRA) conducted a large-scale FOT to evaluate the effects of Intelligent Speed Adaptation (ISA), a system that automatically limits vehicle speed to the posted limit or warns the driver when it is exceeded. In France, the Ministry of Transport sponsored the LAVIA (Limiteur s'Adaptant à la VItesse Autorisée) project, to assess ISA in a test site south of Paris. In 1999, the Netherlands Ministry of Transport also conducted an ISA assessment in the town of Tilburg. The FOT involved 20 passenger cars and some 120 drivers experiencing ISA over an 8-week period. Finally, in the UK the Department for Transport sponsored ISA trials undertaken by the University of Leeds and MIRA Ltd. ISA FOTs have also been conducted in Finland and Belgium.

Japan and Australia have also conducted FOTs. In Japan, vehicle manufacturers tend to use the home market itself as a large-scale FOT for the early evaluation of new systems, and the FOT is seen as an integral part of the research and development chain [2]. In Australia, the only known FOT to have assessed advanced driver assistance systems is the Transport Accident Commission (TAC) SafeCar project which evaluated, alone and in combination, three ITS technologies: ISA, headway warning and seatbelt reminders. In that study, involving 15 test vehicles, 23 fleet car drivers completed 16,000 kilometres of driving over a 5 to 6 month period.

Although the large-scale FOTs conducted previously have yielded important information about the positive and sometimes negative impacts of ITS, the studies have varied widely in terms of their aims and objectives, and the approaches used. As noted by Regan and Richardson [1, page 2], this variability can make it difficult to make robust comparisons between the results obtained. "If, for example, there is inconsistency in the outcomes of FOTs undertaken in two countries to evaluate

Intelligent Speed Adaptation, is this because of technical differences in the systems evaluated or because of differences in study design-related variables (e.g., driver experience and training, test duration, traffic environment, data recording and analysis equipment and protocols, etc)? The ability to draw valid conclusions from the outcomes of different FOTs, which are representative of the subject populations, requires a degree of harmonisation in methodology."

The need for a common approach to the planning and execution of FOTs was recognised by the EC and has been supported through funding of a major collaborative FOT deployment program in the 7th European research framework programme (FP7). The Field opErational teSt support Action (FESTA) project, the first of several in the program, developed a common methodology for planning and implementing FOTs. FESTA was conceived as a necessary preparatory activity for two major EC FOTs – EuroFOT and TeleFOT – that are now underway. EuroFOT is evaluating advanced driver assistance systems (ADAS), while TeleFOT is evaluating nomadic and aftermarket devices.

The FESTA Project
The primary output from the FESTA project was a handbook of best practice for the design and implementation of FOTs [3]. The Handbook describes, in nine chapters, the key issues to be addressed: key steps in planning and running a FOT (Chapter 2 and Annex B); legal and ethical issues (Chapter 3); the selection of functions to be tested, and definition of use cases, research questions and hypotheses relating to those functions (Chapter 4); the selection of performance measures and indicators for testing research hypotheses (Chapter 5); experimental procedures, including participant selection, study design, study environment and pilot testing (Chapter 6); data acquisition (Chapter 7); databases and analysis tools (Chapter 8); data analysis and modelling (Chapter 9); and estimation of the socio-economic impact of the systems evaluated (Chapter 10).

The project adopted a conceptual model for the planning and execution of an FOT that proposed data acquisition as the focus of the FOT with a preceding sequence of data collection activities and a subsequent sequence of analysis activities – the "FOT chain" (see Figure 1) [3]. Annex B of the FESTA Handbook contains a "FOT Implementation Plan" (FOTIP), which, when read in conjunction with Chapter 2, provides a high level checklist for planning and running FOTs. It serves several sub-purposes [1, 3]: to highlight the main activities and tasks that would normally be undertaken in successfully completing a FOT; to ensure that researchers and support teams are aware of important issues that can influence the success of the FOT; to highlight the "dos" and "don'ts" of running a FOT, by drawing on the experiences of those that have run them before; and to provide a consistent framework for planning, running and decommissioning FOTs. The FOTIP takes the form of a table that is 28 pages long.

The content of the FOT Implementation Plan derives from several activities undertaken within the FESTA project [1, 3]: (a) a review of previous FOTs undertaken; (b) a one-day international workshop with FOT experts who had previously conducted FOTs; (c) an international teleconference with experts who had previously conducted FOTs and "naturalistic driving studies" (NDSs); (d) feedback from FOT experts who commented on an earlier draft of the FOT Implementation

Plan; and (e) internal consultation with other members of the FESTA consortium, to identify critical scientific, technical and administrative activities arising from other FESTA research activities undertaken in developing other chapters of the FESTA Handbook.

Information about factors common to FOTs conducted previously was gleaned from the literature. The literature also identified valuable information regarding failures in execution, unanticipated problems and remedial
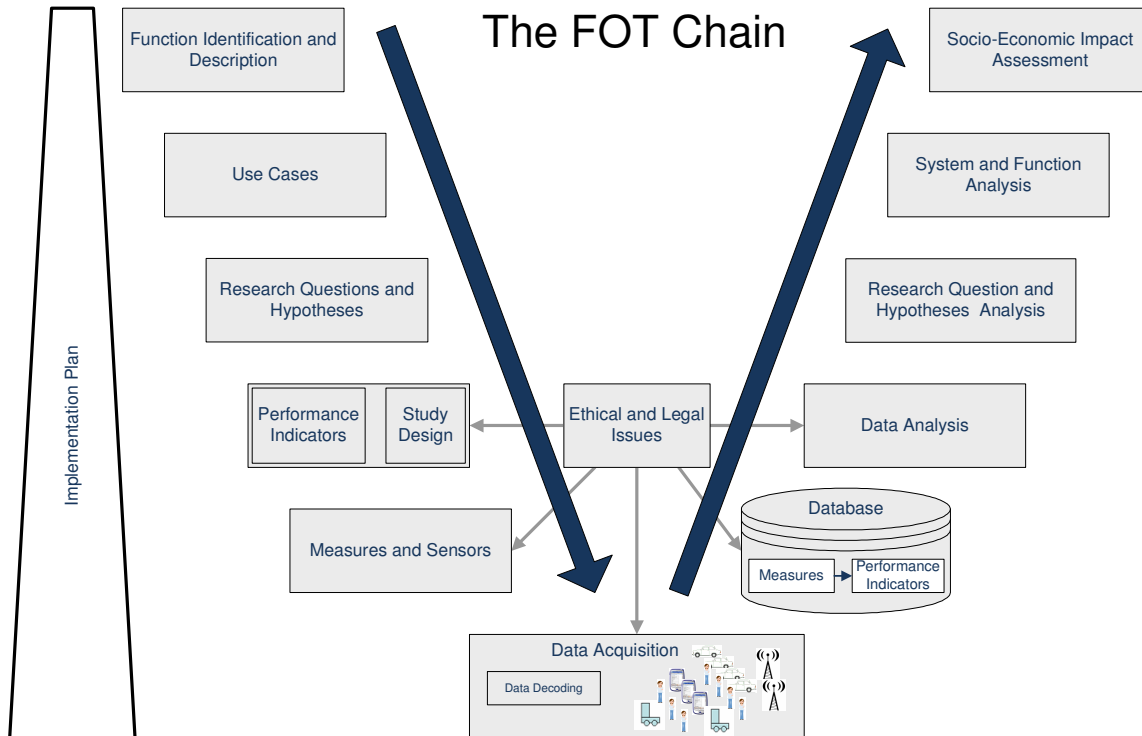

Figure 1. The steps that typically have to be considered when conducting an FOT. The large arrows indicate the time line (drawn from [1]).

measures [1, 3]. However, relatively little information was derived about the FOT planning process. This was secured through the interviews, teleconferences and workshops. In this way, the chronological series of major activities were identified, reviewed and refined. The idea was to provide a guide that would be comprehensive, but also as generic as possible. The FESTA FOT-IP groups these major activities into four common project life-cycle phases: set-up/design, preparation, data collection and completion. Noteworthy is that most of the 22 key activities must be considered in the very first phase of the project (set-up/design), even if they are only a strong focus of activity much later in the FOT [1, 3]. These building blocks and their chronological sequencing are presented in Figure 2.

		Set Up/Design		Preparation	Data Collection	Completion
1	Convene teams and people	▓				
2	Define aims, objectives, research questions & hypotheses		▓			
3	Develop project management Plan		▓			
4	Implement procedures for stakeholders communication		▓			
5	Design the study		▓			
6	Identify and resolve legal and ethical issues		▓	▓		
7	Select and obtain Vehicles		▓	▓		
8	Select and obtain systems and functions to be evaluated	▓	▓	▓		
9	Select and obtain data collection and transfer systems		▓	▓		
10	Select and obtain support systems		▓	▓		
11	Equip vehicles with technologies			▓		
12	Implement driver feedback and reporting systems			▓	▓	
13	Select / implement relational database for storing data		▓	▓	▓	
14	Test all systems to be used according to specifications				▓	
15	Develop recruitment strategy and materials		▓	▓		
16	Develop driver training and briefing materials			▓		
17	Pilot Test equipment, methods and procedures			▓		
18	Run the FOT			▓	▓	▓
19	Analyse the data				▓	▓
20	Write minutes and reports	▓	▓	▓	▓	▓
21	Disseminate the findings				▓	▓
22	Decommission the study					▓

Figure 2 - The 22 key activities involved in planning and running a FOT (drawn from [1])

From the major activities were distilled sub-activities and associated responsible parties. This initial structure was then used as a framework for eliciting the collective knowledge from FOT experts which comprises the critical "dos and don'ts" [3]. This latter information is, to our knowledge, not available in any other published form and provides those planning FOTs with considerable collected 'wisdom'.

The information contained in the FOTIP is too detailed for presentation in this paper. The reader is referred to the original source document [1] for further detail. Regan and Richardson (2008) summarised the key points made in the FOTIP as follows (p. 5) "A FOT is a large and complex activity that requires a dedicated project manager, careful planning and a competent, multidisciplinary, team. Effective communication and coordination within the FOT, and between FOT teams and external parties and stakeholders, is essential. There should be mutual agreement on all risks to all parties

before signing contracts, and all FOT activities should be signed off as they are completed. Legal, ethical, and other obligations and issues must be identified, addressed and resolved early in the FOT. Aims, objectives, and research questions must be identified, prioritized and agreed on by all relevant stakeholders early in the project, as they critically determine everything that follows. To cater for uncertainty, the time and budget required to complete the FOT should not be underestimated.

FOTs generate a lot of information. The project team should document as much information as possible, especially critical procedural knowledge, decisions, problems and lessons learnt. Communication with the media, especially early in the FOT, should be carefully controlled so as not to experimentally contaminate the FOT. The FOT design should include control conditions that enable changes in driver performance and safety (positive and negative) attributable to system exposure to be measured and quantified, and which ensure that the effects observed cannot be attributed to any confounding factors (e.g., seasonal changes in weather) unrelated to the systems being evaluated. The time required for public authorities to provide supporting infrastructure for the FOT is often considerable, and must be anticipated. Project teams should not underestimate the time required to recruit participants, especially from corporate fleets - and should be well prepared for driver dropout. All systems, procedures and equipment should be thoroughly pilot tested before running the FOT, and project teams should ensure that all participants in the FOT know how to operate the systems being evaluated – if not, participants may not use them.

During the FOT, it is critical to ensure that all data is being properly recorded and downloaded, and that participants report technical problems. Project teams should be prepared for emergencies and incidents around the clock (e.g., a crash). It is important to decide early how to manage post-project data – to decide what will happen to it, and who will have access to it. Finally, it is common for FOTs to lose momentum after the final report is written. Final reports must contain practical recommendations for implementation activity, derived in consultation with relevant stakeholders, and key stakeholders must be lobbied to implement these recommendations."

DISCUSSION
The FOTIP describes all known critical tasks and issues that should be considered in planning and running a successful FOT. The authors of the FOTIP, however, provide certain caveats pertaining to its use [3].

There are unforeseen tasks that arise during the lifecycle of a FOT. Hence, the list of tasks is not exhaustive. There may be specific requirements for future FOTs conducted in Europe that will need to be decided on a case-by-case basis.

The FOTIP provides only a rough guide to the order in which Activities and Tasks should be undertaken. The FESTA Handbook lists the 22 Activities identified in the FOTIP, and highlights the main dependencies that exist between them. Within Activities, it is must be decided by the project team which Tasks should proceed sequentially and in parallel.

The authors of the FOTIP offer the following general advice to those who use it [3]: "read through the FOTIP before starting to plan a FOT; use the FOTIP as a checklist both for guiding the planning, design and running of the FOT, and as a quality control mechanism for ensuring during the study that nothing critical has been forgotten; read the FOTIP in conjunction with relevant chapters of the FESTA Handbook; and, if desired, use the FOTIP as the basis for the development of GANTT charts and other project management tools." (pp. 8-9)

The user-centred design of any product usually involves evaluation and, through it, iterative refinement of the product [1]. The FOTIP described here is a product, but it has not been tested for usability. The European Commission has funded under FP7 the two-year FOTNET project, which will create among other things a networking platform for promoting adoption of the FESTA methodology for designing FOTs. It is hoped that this will provide a forum for the collection of user feedback, from those currently running FOTs in Europe (eg euroFOT, TeleFOT), that can be used to refine the FOTIP described here.

CONCLUSION
The FOT is a powerful evaluation tool. This paper has summarised some critical steps, and considerations, involved in planning and implementing a successful FOT, which derive from the FESTA handbook. The FESTA Handbook is already proving to be a useful resource document for those currently planning and commencing FOTs in Europe.

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