

# A COMPREHENSIVE RESEARCH APPROACH TO INVESTIGATE THE PATTERNS OF USE OF IN-VEHICLE TECHNOLOGIES

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**ABSTRACT:** The aim of this paper is to present a comprehensive research approach to identify the patterns of use of in-vehicle technologies by European drivers in everyday driving and their effects on driver's behaviour. This approach; developed within the FP7 INTERACTION project; is based on an innovative combination of well established and new research methods: focus groups, questionnaire survey, naturalistic observations, and in-depth observations. These four methods are introduced and the interest of their combination is highlighted. Then, the added-value of this comprehensive approach is illustrated with the investigation of the patterns of use of in-vehicle technologies.

## 1 INTRODUCTION

Information and Communication Technologies are more and more present in the road transport area. They provide drivers with access to various functions and services which, if designed ergonomically and used appropriately, have potential to significantly enhance driver safety, mobility and comfort. Some of these in-vehicle technologies stay only as the level of prototypes or are still under development. On the other hand, some others are already available on the European market, installed directly by OEMs in the cars, issued from aftermarket or as nomadic devices and the number of European drivers having access to them has grown during the last years. Despite this beginning of adoption by European drivers, little is known about their patterns of use by drivers in everyday life and about their actual effects on driver behaviour and safety.

The investigation of the pattern of use of in-vehicle technologies (IVT) is a broad question which takes on multiple dimensions:

- We need first to identify the driving population using IVT on a regular or occasional basis, as well as non-users. That is to specify the drivers' characteristics and related attitudes that can influence the adoption of IVT.

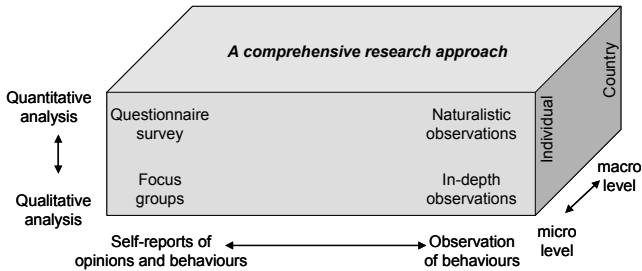
- The drivers' motives to use IVT or not is a second dimension to investigate. It is an important issue to address as the motives of final users can differ from the motives identified by designers.
- The modalities of IVT use by drivers are a third dimension. According to the specific functioning principles of the IVT, we have to identify how drivers interact with their systems and how they configure them, in the everyday driving.
- The identification of the driving context including road, traffic, environment, and trip characteristics where drivers choose to use or not IVT constitute a fourth dimension to investigate.
- At last, the fifth dimension concerns the analysis of the effects of IVT use on drivers' behaviour and road safety and their comparison to expected effects of IVT use.

If the potential benefits of IVT are to be fulfilled, it is critical to investigate these five dimensions of the pattern of use of IVT: to know which drivers adopt these technologies and for which reasons, how, when and where they use them, and what are the effects of these technologies on driving behaviour. By doing so, issues that may limit the adoption of IVT by drivers or induce unsafe use of these technologies can be identified, and countermeasures (e.g., better Human/Machine Interface, design, training, education) can be developed to resolve them.

The aim of the paper is to present a comprehensive research approach to identify the patterns of use of IVT by European drivers in everyday life and their effects on driver's behaviour.

## **2 DEFINITION OF A COMPREHENSIVE RESEARCH APPROACH COMBINING SELF-REPORTS AND OBSERVATIONS**

This approach is based on an innovative combination of well established and new research methods: focus groups, questionnaire survey, naturalistic observations, and in-depth observations. The purpose of this combined approach is to associate, in an only research protocol, self-reports of behaviour and opinions and observations of behaviour by collecting and analyzing both qualitative and quantitative data (Figure 1). This comprehensive approach can also be applied to investigate differences and similarities, in terms of opinions and behaviours, at both micro and macro levels: that is at the individual and country levels.



**Fig.1. A comprehensive research approach.**

The four methods that we propose to integrate in our research protocol are presented more in detail below. Then, their complementarities are highlighted.

## 2.1 Focus groups

A focus group is a qualitative research method in which a small group of people is engaged in a roundtable discussion of selected topics of interest in an informal setting [1][2][3][4]. This method comes from marketing research and consists in asking people about their perceptions, opinions, beliefs and attitudes towards a product, a service or a concept. The discussion is led by a moderator who is in charge of facilitating and stimulating the discussion. A guide provides him/her with the outlines of the discussion.

Typically, a focus group gathers eight to ten individuals. Generally, the homogeneity of the group is an important criterion for its success. For example, when researchers want to study several age groups, they have to repeat the focus group for each age group to favour the exchanges between the participants. In comparison with individual interviews, focus groups with the group dynamics permit to collect a wide set of statements in a limited time slot.

## 2.2 Questionnaire survey

The questionnaire survey is a quantitative method [5], commonly used in empirical social or marketing research; consisting of a series of questions and other prompts in order to gather information from respondents. Questions asked in surveys can either deal with subjective opinions (attitudes of respondents towards a certain topic, their beliefs, their value judgements, etc.) or with knowledge about facts (socio-demographic characteristics of respondents, their living habits, their behaviour, the frequency they are engaged in a specific activity, etc). An important issue is to propose to participants easily understandable questions with clear and comprehensible wording. For that a pre-test of the questionnaire on a small sample is performed before the larger sample is interviewed.

Unlike data collected through focus groups, data gained from a questionnaire survey are subjected to statistical analysis. To allow the generalization of the survey results, the respondents' sample has to be representative of the population that is analysed, the whole population or a specific sub-population. Individual differences can be elicited, by crossing the socio-demographic characteristics of respondents, with their self-reported opinions and behaviours. The analysis of cross-country differences is also possible. For that,

standardised surveys have to be carried out in all relevant countries using the same method and a comparable questionnaire translated in each national language.

Several modes of questionnaire administration exist: face-to-face questionnaire, paper-and-pencil questionnaire for mail survey, computerized questionnaire for web survey or verbal questionnaire for phone survey. These different ways of administration of the questionnaire present each their own bias that has to be considered.

### **2.3 *Naturalistic observations***

Naturalistic observations concern the observation of behaviour in naturalistic settings, in an unobtrusive way, out of any experimental context. In case of driving behaviour observations, participants just drive where and when they want to, at the wheel of their own car, equipped with different sensors and cameras, in order to record information on driver' state, driving behaviour, vehicle dynamics, driving context, etc. Data are recorded non-stop or trigger based during the observation period.

Naturalistic driving studies have been conducted in the USA by various teams of researchers (Highway Safety Research Center of the University of North Carolina, Transportation Research Institute of the University of Michigan, Virginia Tech Transportation Institute) in order to identify drivers' degree of exposure to distraction [6][7], to evaluate the role of distraction in the occurrence of accidents and near-crashes [8] and to evaluate the effects of different kinds of driver assistance systems [9][10]. Through the different Field Operational Tests, such as EuroFOT or TeleFOT, funded by the European Commission, European researchers are also engaged in this kind of data collection.

The feasibility of this approach has been demonstrated by these different studies around the world, as well as the methodological challenges researchers have to face when they want to run this kind of observation [11]. Despite these constraints, naturalistic driving studies offer a unique way to observe driver behaviour in everyday life, out of the artificial side of experiment.

### **2.4 *In-depth observations***

In-depth observations consist in behavioural observations to be carried out in a more controlled way. All participants are observed along the same standardized test route in real conditions of traffic and the observation can be repeated several times for different experimental conditions. These in-depth observations are based on the behaviour observation method named "The Wiener Fahrprobe" [12][13][14].

The method requires one or two observers who sit inside the participants' cars, in order to record drivers' behaviour and to make short term prognoses with respect to future behaviour. One observer registers driving errors, such as disregards for road safety rules, risks taken in manoeuvring, etc. with the help of a standardised coding sheet, meanwhile the second observer registers freely, communication processes with other road users, traffic conflicts etc. Changes in driving behaviour that are expected from any measures, or brought

about by any other changes of the preconditions for driving, are reflected by changes in the predefined behavioural variables.

## **2.5 An innovative combination of methods**

The interest of this comprehensive research protocol lies in the innovative combination of four well established and new methods.

First, the joint analysis of data, issued from self-reports and observations, offers a full investigation of one specific research question. Indeed, self-reports give access to the perception individuals have on their own behaviours and to their opinions related to these behaviours. On the other hand, observations offer an “objective” view of the observable features of human behaviours without the filter of self-reporting.

The sequentially implementation of these four methods in three successive steps permits to integrate the results of the first steps in the research design of the further steps and to confirm in the following steps the preliminary results obtained at the previous steps. Moreover, the qualitative and the quantitative research methods complement each other.

As a qualitative method, focus groups can be used as a preparatory step before a quantitative research, such as a questionnaire survey. They help researchers to refine the research hypothesis raised by the literature review and to generate new ones. They can also provide useful outcomes for the design of the questionnaire. On the other hand, the survey can confirm, with a large sample of people interviewed, the preliminary results obtained by the focus groups. The survey is also a powerful tool to contribute to the design of the observation phase with the identification of the population that has to be observed.

The naturalistic driving observations and the in-depth observations complement each other. The former one, with the possibility to observe drivers during their usual journeys and during long period of time, permits to collect and to analyse, in an ecological way, drivers’ actions, (even if these actions are not so frequent) and their associated effects on driving. The latter one, by the integration of experimental constraints during the observation and by the presence of the observers in the car of participants, permits an easier measurement of behavioural changes and a qualitative diagnosis of some complex behaviour such as the interpersonal communication process between road users.

The questionnaire survey on a large sample and the inclusion of different groups of individuals in the observation phase offer the possibility to study the differences and similarities in terms of opinions and behaviours at the individual level. The implementation of this research protocol in different countries allows to complete the study of these differences and similarities at the country level.

The figure 2 shows the functional interactions between the four methods.

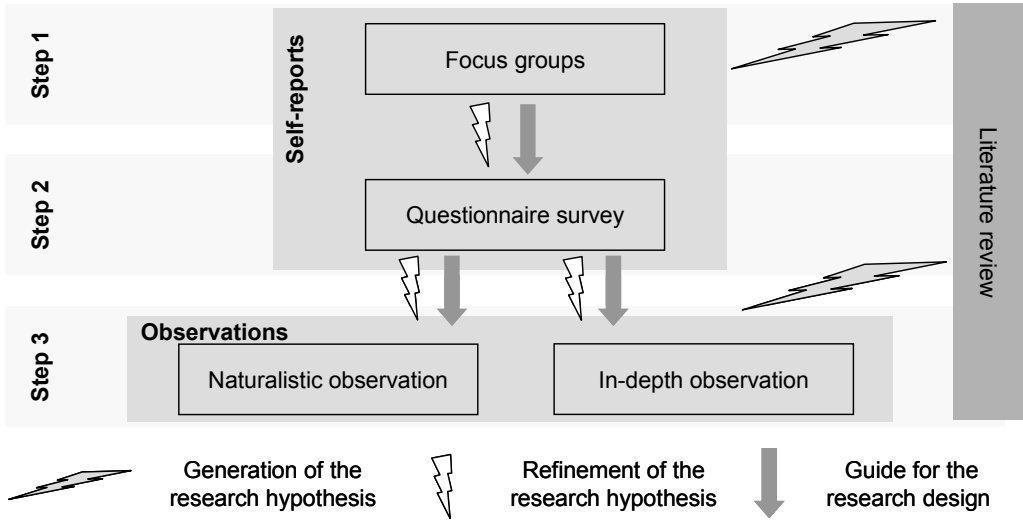


Fig.2. Complementarities of the four research methods.

### 3 IMPLEMENTATION OF THIS RESEARCH APPROACH TO INVESTIGATE THE PATTERNS OF USE OF IVT

This comprehensive research framework is currently being implemented within the FP7 INTERACTION project. The objective of this European project is to gain a better understanding of driver interactions with IVT, to identify patterns of use of these systems by European drivers in everyday life, to analyse their effects on driver's behaviour and skills, in normal and emergency situations and to highlight individual and cross-country differences. Amongst all the available IVT, INTERACTION focus on a limited set of mature technologies, already available on a wide range of car models or available as nomadic devices, such as cruise control, speed limiter, navigation systems and mobile phone. The project includes a cross-country study between 9 countries with various cultures, driving habits, car fleets, relations to new technologies and various legislation and enforcement regimes related to road safety

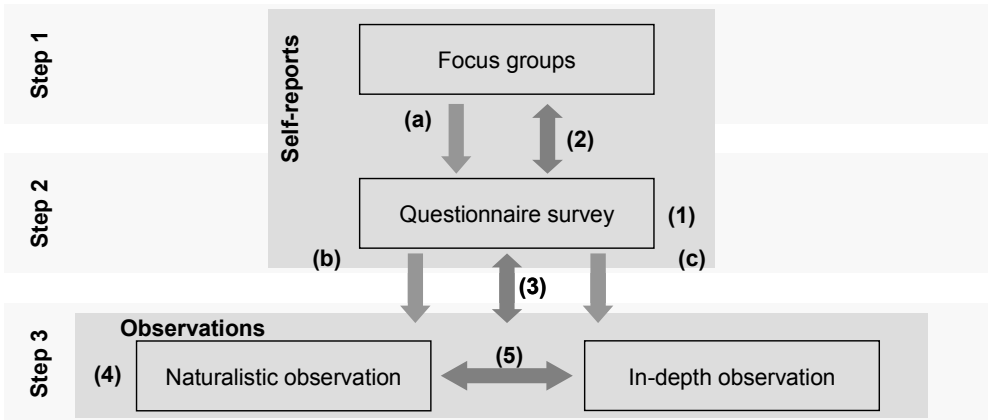
The combination of the four methods allows to investigate the five dimensions of the patterns of use of IVT (Figure 3).

A set of focus groups with drivers having the selected IVT permits to gather information about the different contexts in which drivers use these systems, their eventual misuses, the difficulties or critical situations they met. The advantages and disadvantages of the systems were also discussed. With the focus groups, partners broached the motives of drivers to use IVT and the driving context in which they favour or avoid using them. Lastly, to highlight potential individual and cross-country differences in terms of technologies appropriation, three groups of drivers are investigated: young drivers, standard drivers and experienced drivers and the focus groups are run in several

countries.

In a second step, a web questionnaire survey is conducted simultaneously in the nine countries involved in INTERACTION. A sample of 1000 IVT users among the European drivers population, in every participating country, is being asked to complete a web-questionnaire with the first objective of describing the population of drivers that have and use these technologies in a regular or an irregular way and to evaluate differences or similarities between countries. A set of questions permits to ask drivers on the benefits of IVT, on their usefulness in different driving context, on their ergonomics and reliability, and on their positive or negative effects on driving. The analysis of respondents answers permits on one hand, to understand their motives to use or not to use these technologies and on the other hand, to precise in which context drivers report using them.

The third step of the research protocol concerns the observation of driver interactions with IVT, The instrumented naturalistic driving study permits to observe and collect a variety of real-time data from a sample of drivers at the wheel of their own vehicle during a sufficient time period for identifying their patterns of use of these technologies in everyday life and their implication for safety. That is to identify when and where drivers use IVT, by analyzing driving contexts of IVT use in terms of road characteristics, traffic flow, weather conditions, time of the day, trips characteristics, ... The aim is also to study how drivers use IVT, by identifying how drivers choose to configure their systems and what sequences of actions they preferentially perform for selecting, setting or disengaging their systems. In parallel, in-depth observation allows comparing drivers' behaviour when they interact or not with IVT during observation rides on a standardised route. Potential changes in driver's skills and behaviours in critical situations as well as the potential changes in the driver's behaviour in the communication and interaction with other road users are then investigated.



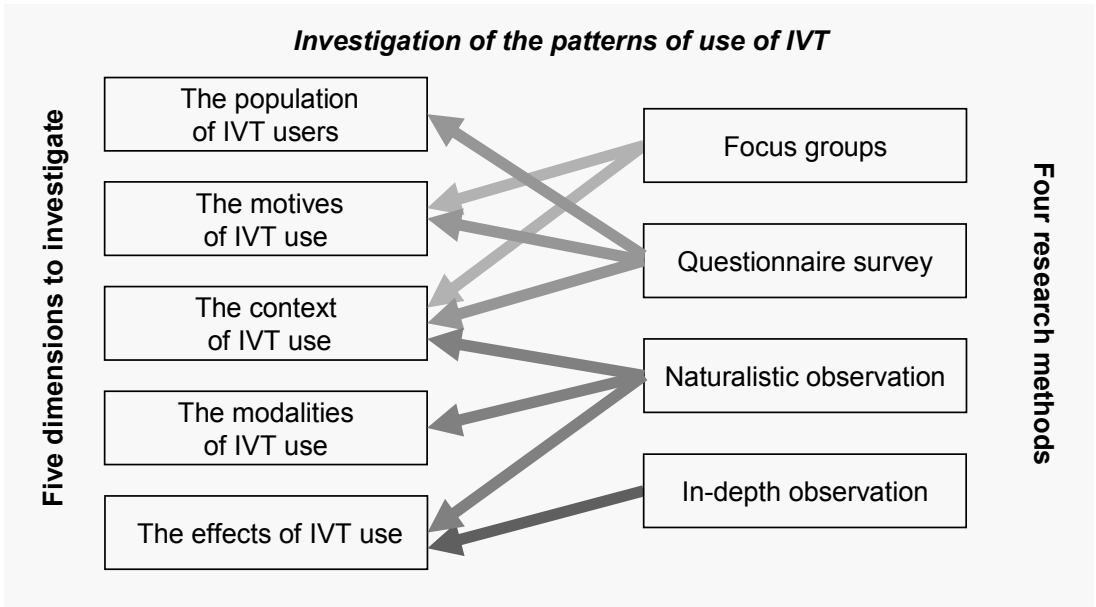
- (a) Inputs for the design of the questionnaire
- (b) Inputs for the definition of the observation period
- (c) Inputs for the definition of the driver sample
- (1) Investigation of the population of IVT users
- (2) Joint investigation of the motives of IVT use
- (3) Joint investigation of the context of IVT use
- (4) Investigation of the modalities of IVT use
- (5) Joint investigation of the effects of IVT use

**Fig.3. Implementation of the research approach to investigate the patterns of use of IVT.**

These four research methods are fully complementary (Figure 4). Only two dimensions of the patterns of use of IVT are studied by only one method. It is the case for the description of the population of the IVT users that will be done through the questionnaire survey analysis and the identification of the modalities of use of IVT with the naturalistic observation. The three other dimensions, the motives of IVT use, the context of IVT use and the effects of IVT use, are investigated with at least two methods that complete each other.

The results obtained at one step contribute to the design of the methods implemented at the next steps. The results of focus groups contribute to the design of the questionnaire used during the second step of the research protocol. On the same way, the analysis of the answers of the respondents to the questionnaire survey permits to identify the criteria used to include drivers in the sample of participants for the observation step and to specify the duration of the observation period for the naturalistic observation according to the average frequency of use of each system.





**Fig.4. Complementarities of the four research methods to investigate IVT patterns of use**

In order to achieve significant results for the cross-country study, it is important that the research protocol, based on the combination of the four methods, is implemented in the same way by each partner. Indeed, the cross-country study requires an equivalence of the research instruments and a consistency of data collection and processing in the nine countries involved in the project. If all the partners do not commit to implement the methodologies in the same way, it may cause a global decrease in the general quality of research outputs.

This commitment in a cross-country study is a specificity of the INTERACTON project in comparison with other European projects studying the effects of IVT on driving behaviour. It induces for the project strong constraints in terms of technical management and quality control in order to provide relevant results.

#### **4 CONCLUSION**

This paper presents a comprehensive research approach developed in the framework of the INTERACTION project to identify the patterns of IVT use by European drivers in everyday life and their effects on driver's behaviour. This approach is based on an innovative combination of four research methods: focus groups, questionnaire survey, naturalistic observations, and in-depth observations. This combination offers the opportunity to merge results of qualitative and quantitative analysis and results issued from self-reports and observations.

The INTERACTION project started end of 2008 for 42 months. The first 18 months of the project are devoted to the design, running and analysis of the two methods based on self-reports of drivers' opinions and behaviour related to their interactions with IVT. The preparation of the last step of the research protocol devoted to the observations is also on progress.

## **5 ACKNOWLEDGMENTS**

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