The Netherlands
Research School for
Transport, Infrastructure
and Logistics
TRAIL

11th TRAIL Congress
November 2010

A DELPHI STUDY INTO VEHICLE POSITIONING TECHNOLOGIES FOR ROAD PRICING

The case of nationwide distance, time and place-based systems

Diana Vonk Noordegraaf MSc, Jan Anne Annema PhD
Faculty of Technology, Policy and Management, Department of Transport and Logistics,
Delft University of Technology, the Netherlands

ABSTRACT

Many countries have expressed the ambition to implement advanced nationwide distance, time and place-based road pricing schemes for freight and passenger transport. GPS technology for vehicle positioning is most suitable for these schemes but has worldwide only been applied to one scheme (German road pricing system). This abstract presents a Delphi study (work in progress) in which experts are invited to assess how feasible several GPS technology options are for supporting advanced road pricing schemes, as this is still uncertain. This study especially focuses on the expected developments of *technical design variables* (e.g. positioning accuracy, system costs, complexity, security and privacy and flexibility).

KEYWORDS

Road pricing, Delphi, Global Positioning System (GPS), feasibility, multi criteria

INTRODUCTION

Recent technological developments enable the implementation of road pricing schemes. For example, Dedicated Short Range Communication tags are widely applied for tolling (Lee et al., 2008). There is range of available vehicle positioning and communication technologies. Which combination of technologies is most suitable depends on the specific characteristics of the road pricing scheme (Vonk Noordegraaf et al., 2009). This study focuses on advanced nationwide distance, time and place-based road pricing schemes for freight and passenger transport. These schemes require a positioning technology to determine road usage. GPS technology allows for the registration of distance, time and place and is relatively flexible (Lee et al., 2008). GPS is therefore considered suitable to support such schemes. Furthermore, GPS primarily uses in-vehicle technology (instead of roadside equipment) which is an advantage for nationwide applications (Vonk Noordegraaf et al., 2009). The extensive technical possibilities are for example acknowledged by the governments of France, Belgium,

Denmark, United Kingdom, Switzerland and the Netherlands. All these governments have proposed advanced nationwide road pricing schemes. However, to date these proposals are stalled or did not gain sufficient political support. Germany has implemented a nationwide distance-based road pricing scheme based on GPS technology (Borgnolo et al., 2005, Link, 2008). However, this scheme is limited in scope because it only applies to trucks and not to passenger cars.

The overall feasibility of a (advanced) road pricing scheme depends on the economic, technical, societal and political feasibility (Feitelson and Salomon, 2004). This paper focuses on the technical design variables. GPS technology options can be simple as well as more complex (e.g. enhanced with map matching). The objective of this study is to map experts' assessments of the performance of various GPS technology options on criteria relevant for the case of advanced road pricing schemes. The experts will for example be asked to assess the positioning accuracy of each option which determines how feasible the options are to support a tariff differentiation to place. In addition, the experts will be asked to identify dependencies between the technical design variables (higher accuracy is expected to result in higher costs) and the developments they expect concerning these variables. Together, this will give an overview of the technical design space for advanced road pricing schemes. Mapping and interpreting the expert's views may result in policy-relevant information. For example, if a GPS option is not feasible because it does not meet the specified requirements (e.g. too costly of insufficiently accurate) a policy maker can decide to reformulate the requirements (and redesign the policy) or choose an option that best meets all requirements. The study results can be used to support the cumbersome design and implementation processes of advanced road pricing schemes. In addition, the outcomes of this study will update the scientific knowledge on the state-of-the-art performance of these technology options.

BACKGROUND AND RELATED WORK

Technical feasibility is crucial for a successful implementation of a road pricing scheme. Often a combination of technologies (e.g. for positioning, communication, data processing) is used (Lee et al., 2008). 'The ability to locate and track a vehicle in space and time is fundamental to charging for true road use.' (Ochieng et al., 2008:1). The focus of this study is therefore on positioning technologies. The overall performance of a positioning technology is determined by the combination of technical design variables. Persson et al. (2007) give a comprehensive overview of criteria to asses technologies for road pricing which is complemented by Vonk Noordegraaf et al. (2009). From these papers the primary categories of technical design variables, being positioning accuracy, system costs, complexity, security and privacy and flexibility, are derived.

Although the literature on road pricing is abundant (see Verhoef et al., 2008 for references), there are not many articles focusing on technologies for road pricing. Some articles describe a specific road pricing scheme including the technology (e.g. Rye et al., 2008). There are few articles that discuss different technologies that can support road pricing (e.g. Lee et al., 2008, Bertini and Rufolo, 2004, de Palma and Lindsey, 2009), but these do not particularly focus on application for advanced road pricing schemes. There is also literature that focuses on a specific technology. For example Stopher et al. (2008) discuss challenges of using GPS to measure travel patterns.

It is uncertain to which extent GPS can meet the challenging requirements for advanced road pricing schemes. Blythe (2005) expects that despite great challenges, satellite-based solutions

(such as GPS) for road pricing will become available in the coming decade. The implementation of the German road pricing system proved that this expectation was correct. However, further empirical evidence on the feasibility of GPS for advanced road pricing schemes is lacking. Cottingham et al. (2007:519) conclude that 'a national-scale, pervasive, location-based congestion charging system is not technically achievable in the short-term.' On the other hand, positioning technologies develop rapidly. Therefore it is relevant to update the scientific knowledge on the feasibility of GPS for road pricing with the state-of the art insights.

RESEARCH METHODOLOGY

GPS develops rapidly making literature soon out-dated (Stopher et al., 2008). Grey literature, is generally more up to date. However, finding these sources and having access is more complicated and the quality is often uncertain. Therefore, the viewpoints of experts are considered a valuable contribution. Consulting experts is relevant when it is not valid to extrapolate past developments, which is the case for uncertain technology developments (Marcheau, 2000). Furthermore experts can provide valuable contributions to multi criteria technology assessments (Shen et al., 2010).

There are different ways of consulting experts. Examples include face-to-face interviews, group interviews and surveys. For this study we choose for a Delphi survey. A Delphi study consists of a series surveys 'to accumulate, to pool and to appraise expert opinions' (Steinert, 2009:292). After the initial survey each subsequent survey, a round, is accompanied by (anonymous) feedback from the researcher on the information provided by all experts. This has the advantage of offering experts the opportunity of reconsidering and modifying their answers based on the feedback, without the difficulties encountered in group interviews such as dominance of one expert. Furthermore, it is not necessary that experts have to be at the same place and time simultaneously.

Although traditionally a Delphi aims for consensus (Steinert, 2009) it can also be used in explorative studies as is the case here. This study will make use of web surveys which have the advantage of shorter transmitting time, lower delivery cost, more design options, and less data entry time (Fan and Yan, 2010). The main disadvantage is a lower responses rate (Fan and Yan, 2010). Contrary to many web based Delphi studies, we did not choose for a 'roundless' design. Although this saves time and is efficient (Gordon and Pease, 2006), it has the disadvantage of the 'lack of reminders throughout the process' (Geist, 2010:153). Furthermore, the advantage of having rounds is that the feedback includes the information of all experts. To reduce non-response and drop-out, the number of rounds is limited to two. International experts (scientists, industry experts and consultants) from a variety of disciplines (related to the technical design variables) will be invited for the study. The selection is based on the experts' number of relevant publications and on recommendations of other experts.

This study will result in an overview of experts' assessments of the performance of various GPS technology options on criteria relevant for the case of advanced nationwide distance, time and place-based road pricing schemes. Furthermore experts' views on dependencies between and developments of the technical design variables positioning accuracy, system costs, complexity, security and privacy and flexibility will be mapped. The results are expected to be relevant for policy makers and scientists involved in (re-)designing advanced road pricing schemes.

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