State-of-the-art Technologies for Post-Trip Safety Interventions

Eva Michelaraki[a], Christos Katrakazas*[a], George Yannis[a], Ashleigh Filtness[b], Rachel Talbot[b], Graham Hancox[b], Fran Pilkington-Cheney[b], Tom Brijs[c], Kris Brijs[c], Veerle Ross[c], Hélène Dirix[c], An Neven[c], Roeland Paul[c], Petros Fortsakis[d], Eleni Konstantina Frantzola[d], Rodrigo Taveira[e]

[a]National Technical University of Athens, Department of Transportation Planning and Engineering, 5 Heroon Polytechniou str., GR-15773, Athens, Greece

[b]Transport Safety Research Centre, Loughborough University, Loughborough, LE11 3TU United Kingdom

[c]UHasselt, School of Transportation Sciences, Transportation Research Institute (IMOB), Agoralaan, 3590 - Diepenbeek, Belgium

[d]OSeven Single Member Private Company, 27B Chaimanta Str., GR-15234, Athens, Greece

[e]Barraqueiro Transportes, Avenida Santos e Castro, 1750-265, Lisboa, Portugal

*Corresponding author: ckatrakazas@mail.ntua.gr

ABSTRACT

Several systems and methods have been investigated in order to develop an appropriate driver monitoring and mentoring strategy after each trip. The i-DREAMS[1] platform allows the implementation of post-trip interventions, meant to motivate and enable human operators to develop the appropriate safety-oriented attitude in the future. Hence, the scope of this paper is to investigate the state-of-the-art technologies utilized in four different transport modes (car, truck, bus and rail) for post-trip interventions associated with risk prevention and mitigation. Overall, several smartphone applications and web-based platforms have been explicitly designed for providing post-trip feedback to drivers, in order to identify risky driving performance, improve their behaviour and promote road safety. With regards to car-specific interventions, driver systems with gamification features and visual notifications enabled drivers to achieve a better performance. In addition, smartphone applications were found to offer a scalable, and easily implementable alternative to current road monitoring methods, although methodological challenges still remain. In trucks and buses, interventions were usually part of a broader framework (e.g. including driver coaching and management commitment) and the effects of such interventions was not be taken into account in isolation for accomplishing a sufficient safety culture change. Lastly, as of yet no post-trip interventions to improve rail drivers' safety appear were identified in the literature.

Keywords: post-trip interventions, state-of-the-art technologies, smartphone application, web-based platform, transport modes.

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1. BACKGROUND

In recent decades, the introduction of automotive telematics and driver monitoring systems in the industry have created the ability to provide post trip interventions to the driver. Post-trip feedback gives drivers the opportunity to identify their weak points, adjust their potentially aggressive or dangerous behaviour and promote eco-driving style. Additionally, through delayed feedback, driving skills during future trips could be improved and the driver could be reinstated in a safe driving field. The intervention tools provide guidance and notifications to drivers with a focus on enhancing knowledge, attitudes, perception and eventually safety performance.

As the need for driver monitoring systems is becoming increasingly important, the European Commission H2020 project i-DREAMS aims to define, develop, test and validate a context aware safety envelope for driving, i.e. "Safety Tolerance Zone" (STZ). The main purpose of the project is to determine the STZ and monitor if drivers are within acceptable boundaries of safe operation (Michelaraki et al., 2021; Katrakazas et al., 2020).

With regards to its structure, this study begins with a theoretical background of post-trip interventions, as detailed in several studies and then, the main objectives of this research are provided. In addition, an overview of traditional survey methods is provided for completeness. The results of each post-trip intervention technology and recording tool obtained from the international published literature are mentioned. The paper concludes with the impact and a critical synthesis of the most useful technologies and systems that were examined for calculation of the "Safety Tolerance Zone".

2. OBJECTIVES

The objective of this paper is to critically review and assess the state-of-the-art in user feedback and post-trip safety intervention technologies for each transport mode. For that purpose, a literature review was conducted within the i-DREAMS project in order to identify measurement methods and their targeted operator state factors. Technologies corresponding to the four modes included in the i-DREAMS project (i.e. car, truck, bus and rail) are distinctively examined in order to review technologies that might perform better in a specific mode. With regards to the last transport mode, it should be mentioned that train and tram are both combined under the term rail.

3. METHOD

In order to perform a systematic literature review, the search terms were initially identified, then the abstracts and titles were screened as per their relevance, and finally the most relevant papers were overviewed in order to identify the technologies most crucial for improving driver performance, after the trip. Focus was given on the driving performance characteristics (i.e. speed, harsh events, distraction), the indicators used to measure those constructs, the technical equipment as well as the results and conclusions with respect to the scope of the i-DREAMS project. Relevant studies were located using popular scientific databases and repositories, such as ScienceDirect, Scopus, Google Scholar, and PubMed. Table 1 depicts the search terms used per factor analysed, as well as the number of screened and included papers.

Table 1: Search terms and screened and included papers per factor analysed

Mode	Search terms	Screened papers	Included papers
Cars	"post-trip interventions" OR "post-trip feedback" OR "interventions" OR "feedback technology" AND "cars" AND "car drivers"	116	9
Trucks	"eco driving truck app" OR "safety app trucks" OR "trucker apps safe driving" OR "trucker apps feedback" OR "telematics trucks" OR "truck coaching app" OR "truck telematic driving behaviour" OR "truck driver behaviour app" OR "truck behaviour feedback"	44	4
Buses	"post-trip interventions" OR "post-trip feedback" OR "feedback" OR "interventions" OR "telematics" OR "feedback technology" AND "bus" AND "bus driver"	101	7
Rails	"post-trip interventions" OR "post-trip feedback" OR "feedback technology" AND "rail" AND "train drivers" OR "tram drivers"	10	0

4. RESULTS

4.1 Cars

Post-trip feedback using web platforms has been recently investigated in many studies (Braun et al., 2015; Takeda et al., 2012) with regards to cars. To begin with, SAGA technology provides feedback to drivers and encourages them to adopt a safer behaviour (ECMT, 2006). Weekly summary reports were sent to drivers by email and it was revealed to be an effective solution, as drivers managed to reduce their crash rates per 50%. Moreover, IVDR systems such as DriveDiagnostics, were found to have high performance and relatively low cost, providing monthly web-based reports (Toledo et al., 2008). In addition, smartphones offer a scalable, cheap and easily implementable alternative to current road monitoring methods, which can be easily transferred to other transport modes (Chaovalit et al., 2014). The majority of applications were designed to detect harsh events and mobile phone use, analyse sensor data and provide a performance score. OSeven, Zendrive, TrueMotion, TheFloow, Sentiance, Octo Telematics and VivaDrive were the most reliable smartphone applications which were evaluated for their acceptance and effectiveness, providing immediately post-trip feedback.

4.2 Trucks

With respect to trucks, it was found that truck-specific systems paid a great deal of attention not only to safety but also to eco-driving. It was revealed that D2go, Next Driver and Truck Hero, were the most effective technologies combining in-vehicle behavioural monitoring with immediate post-trip interventions. In addition, DAF Connect was found to be the best eco-friendly solution proving delayed feedback and helped drivers to be more self-aware and motivated. The benefits of using gamification

with post-trip intervention appear to be increased motivation and engagement with the intervention. The results obtained with respect to trucks indicated that although a combination of monitoring and gamified feedback resulted in the best driving behaviour after the trip, it was clearly mentioned that such interventions were not provided in isolation. This kind of feedback was usually embedded within a broader safety change intervention framework in which they were offered in combination with other strategies (i.e. driver coaching and management commitment and support). Finally, it should be mentioned that most of the truck applications provided visual post-trip feedback to fleet operators that can easily be transferred to other transport modes.

4.3 Buses

With regards to buses, Green Telematics and Scania Optimile Fleet Management, intervention systems were found to be the most comprehensive for practical implementation and operators have the opportunity to identify driver's performance and plan targeted training activities. Moreover, DriveProfiler, Jaltest Telematics and Pure Telematics technologies had a positive effect on bus driver's performance and provided detailed post-trip reports to the fleet managers from embedded smartphone applications and a web-based portal. Lastly, FuelSave and Stratio Automotive systems found to be the less effective solutions for post-trip interventions. It is worth mentioning that detailed knowledge relating to professional bus drivers' attitudes, perception and performance concerning economy and safety binomial is required in order to change and improve the behaviour.

4.4 Rails

The results on post-trip interventions for rail suggested that there was not a diversity of technologies and systems providing feedback to tram/train drivers. None of the relevant studies identified in the review gave detailed findings on a post-trip intervention but instead theorised how a gamified application could work in the rail industry.

5. IMPACT

Post-trip feedback has the potential to affect long-term behavioural change. This paper aimed at critically overviewing the state-of-the-art literature on post-trip intervention technologies to promote safe driving. The findings from this review could be used to inform considerations for recommending technologies which may be effective in both simulator and naturalistic driving testing.

With regards to car-specific interventions, driver telematics with gamification features as well as visual warnings and proposals for better driving performance were deemed more appropriate. The results obtained with respect to trucks confirmed that although a combination of monitoring and gamified feedback resulted in the best driving behaviour after the trip, it was clearly mentioned that such interventions were not provided in isolation. With respect to professional fleet operators, the benefits of post-trip intervention systems may vary depending on whether the employer has access to information about the individual drivers or not. Although there were different interventions for improving rail security compared to other transport modes, evidence from the literature demonstrated that visual warnings could enhance driver alertness in post-trip.

Consequently, based on the list of post-trip intervention technologies listed, researchers and practitioners could implement the technologies that aligned closely with their operation. Priority should be given to the form of feedback, as well as the integration with the existing web-platforms and sensor equipment included in the trials. It should be mentioned that post-trip intervention platforms should not replace other intervention approaches but should act as a complement to other actions taken to improve road safety and eco-efficiency. Identifying the most suitable interventions for triggering and accepting feedback will therefore maximize the effect on safety among all traffic users.

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