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Impact of telematics-enabled devices on driver behaviour

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ABSTRACT
Interaction between the driver and transport telematics is the focus of this paper. In its first part, methods of attracting driver's attention and affecting them were analysed, with the use of feasible information displays. Potential hazards were also investigated. It latter part, research regarding driver attitude towards route planning using in-vehicle telematics was presented.

KEYWORDS: driver behaviour, MMI, telematics

1. Introduction

Traffic Control Systems have been developed for many years, and ultimately started to make use of telematics solutions. That way Intelligent Transport Systems were born. Nowadays, the term ITS is commonly associated with interactive systems designed to collect, process and distribute information concerning surface transport. That purpose integrated information solutions and telecommunications technology are used as part of road infrastructure and often coming with in-vehicle equipment.

Intelligent Transport Systems provide a channel for exchanging information between infrastructure components, vehicles, drivers and other transport users maintained by traffic centres in a way that information critical for the recipient are fed in real time and in a digestible form [9]. The widest group of ITS system users are the drivers themselves, whose vehicles are ever more commonly equipped with on-board telematics. Those systems are supposed to support driving, however, they could also have a negative influence on driver behaviour, or could even potentially cause accidents. Above issues give grounds for writing this paper.

2. New technologies and their impact on users

Acceptance for new technical solutions is closely linked with psychomotor abilities. It has been proved that age, intelligence and frequency of using modern technical solutions and gismos determines what attitude one has towards latest technical crazes and solutions [1, 4]. Research that has gone into this matter seems particularly important in the last few years, where the development of telecommunications and IT has been immensely dynamic. A conclusion may be drawn that people uninterested in using computers, mobile phones or recently popular smartphones and tablets have every right and can afford to abstain from those solutions in their everyday lives. In terms of telematics that same choice is very much limited given current trends in the automotive sector and inevitable world-wide presence of ITS systems.

2.1 Human - ITS communication

According to what has been written in the introductory part, ITS is charged with collecting, managing and sharing information that has direct connection to the transport process. Different sensors are used for that purpose, ICT systems and MMI interfaces (Man-Machine Interface) installed both in road-side infrastructure as well as the vehicles themselves. Sensors and communication system may very well run in the background remaining unnoticed by the drivers who are oblivious to their presence, however, communication interfaces are the evident manifestation of each of those systems surrounding the driver [7].

MMI interfaces may be broken down into two groups: First one is the road-side infrastructure devices. They include road signals, variable message signs and Dynamic Route Guidance Systems. Road signals may be classified as widely known and popular solutions which directly control road traffic. Variable message signs and boards are more of a advisory systems, which do not have to be observed by the driver. Acceptance for those solutions among the drivers is very high, because both the signals and other interfaces are widely-known from former solutions used on roads for many years. Among the differences emerging from introduction of ITS systems is that a predefined signal cycle may be interrupted and adjusted due to disruption or extraordinary event e.g. coming through emergency vehicle (e.g. ambulance, vehicle carrying hazardous materials, police etc.). The same applies to variable message signs and notice boards, however, the content they present are dynamically adjusted to address current weather conditions and events which could affect routing.

The other group of interfaces are telematics-enabled devices installed on-board vehicles. It receives the biggest attention from car manufacturers and is used for marketing campaigns convincing potential buyers to settle their choice on any particular brand.

Fig. 1. Dashboard of a car equipped with telematic system

In-vehicle MMI interfaces may be classified under two categories. Visual systems are the first one. Information about vehicle status and its surround are: instrumentation and controls housed by the dashboard, gauges, displays located at dashboard height and semi-transparent panel glued to the windshield. It is worth pointing out that ten years back only luxury segment cars were equipped with information displays. Owners of different cars could retro fit additional, standalone PNA solutions. Nowadays on-board, built-in displays ever-often come as standard in mid-range, middle segment cars. Head up displays have been emulated by car manufacturers after military aviation and are rather rarely used, however, over the next decade a change in that respect shall be expected, since this solutions is more natural for the driver and less distracting than conventional instrumentation.

The other interface category is sound systems. At the beginning they were based on primitive sound communication using a repository of pre-recorded messages which were intended to draw driver's attention e.g. unfastened seatbelt, icy-bound road surface as well as lights left on and windows open. Modern solutions ever more frequently use voice commands much more natural for people. At the same time, in Europe still popular, although obsolete solution, is German RDS (Radio Data System) using on-board radio to feed road information. Nowadays, in age of advanced ICT solutions, IVR (*Interactive Voice Response*), TTS (*Text-To-Speech*) are preferred as well as VR (*Voice Recognition*). Those systems allow to convey voice information about vehicle status, road situation, any potential traffic disruptions or road surface conditions. At the same time, the driver can make voice commands concerning i.e. controlling the in-vehicle car audio, rerouting the navigation system, controlling built-in electronics (e.g. electric windows, door mirrors, driving mode etc.), using mobile phone via the hands-free loudspeaker system (remote calling), anti-vandal systems, eCall and emergency stop.

2.2 Driver distraction

Introduction of new telematics interfaces communicating with the driver should be preceded by a scrupulous assessment of benefits and potential hazards it causes. The overarching rule here is "first, do no harm", which should be reflected by ergonomics of interfaces. Ergonomic, in-vehicle MMI telemactics interfaces should be designed based on driver psychological tests. They may provide answers as to how should an interface communicate with the driver, what should be its intensity, how effective it is, how easy to use etc. The very first, serious, research in that respect was published by [3]. The design process is also influenced by human reactions. The attempt to model them were undertaken in paper [5]. According to the author, the reaction should be assessed by impact of persuasion on driver reaction rate.

The fundamental hazard caused by new telematics-enabled devices is driver distraction and its level depending on external stimulus. Police statistics should serve as documentation for this problem. They indicate the number of road collisions caused by driver distraction due to phone conversation during driving, momentary loss of attention by checking PNA device or on-board display. Unfortunately, according to information provided by the Spokesperson of the National Police Commander in Chief, at this time there is no such research. It is only the press, who present more spectacular cases. Influence of GPS devices of driver behaviour has been somewhat documented by the paper [6].

How a driver is at ease using information fed be telematics-enabled systems depends on driver's age, driving experience and literacy using given interface. Driver`s fatigue also plays an important role. All of the above-mentioned factors should determine volume level of sound messages, size of button displayed on MMI screen as well as colour scheme and size of provided information. To author's best knowledge, there is no such research, which would concern developing telematics into a more adaptive system. Box-standard, off-the-shelf solutions installed currently in vehicles have little flexibility in presented displayed content. Consequently, there is a need for wider research and analysis in that respect.

2.3 Driver Acceptance for Telematics-Enabled Technology

Advances in automotive technology, particularly in recent years, have led to popularising and widespread use of in-vehicle interfaces for hands-free phone calls, parking sensors and satellite navigation (GPS). Majority of the drivers purchasing cars equipped with the aforementioned, accept their function and use them. Some of the drivers are particularly satisfied immediately after the purchase, provided the devices are independent enough not to require constant attention from the driver and their interface was successfully learned by the user. Among reasons behind negative reception of the new, in-vehicle technology are: driver`s age, complicated operation, problems with synchronization of additional devices, extra fees for using the system or telematic services.

A much more interesting aspect is driver`s assessment of telematics interfaces over the long-term. Research results provided by author of this paper are indicative of that. Some of the drivers who initially were enthusiastic about the new on-board telematics-enabled features, after some time, become accustomed to the system and eventually indifferent to it. On the other hand, the drivers with reservations towards the new technology at the start, with time became more at ease with it and ultimately showed acceptance for it. Among people from the latter group, change in attitude was often caused by third parties as well as random events, when telematics worked, assisted rectifying a predicament and thus made its mark.

The last factor critical for acceptance of telematics system is its effectiveness. Should driver notice certain deficiencies and shortcomings in its operation, it might cause disappointment and deter from further use.

3. Travel planning and new ITS solutions

New, in-vehicle driver aiding devices have a far reaching impact on changing route planning. In this part of the paper, research results concerning usability of telemactics solutions and their impact on travel planning were presented. The example shows American drivers commuting to work and returning home, travelling in total 80 km between Laurel, MD and Dale City, VA between 6:30 am and 6:30 pm. Drivers were using a road network consisting of 55 nodes all of which could have been used to alternate the commuting route. The research was conducted in August and September of 1999 over 39 business days.

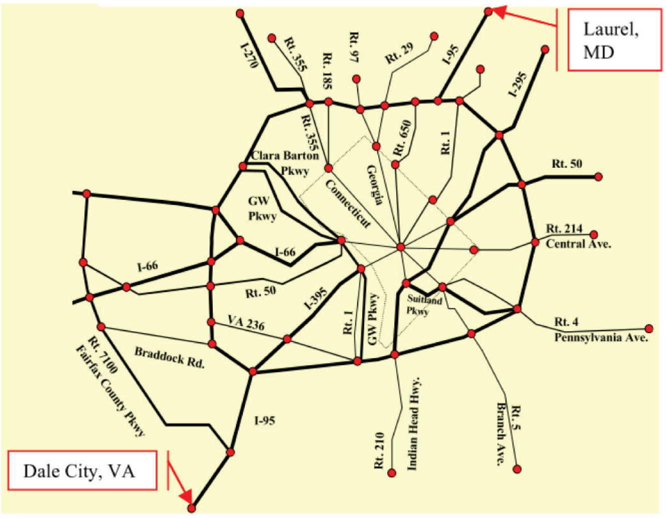

Fig. 2. Road network between Dale City and Laurel [8]

Examined drivers were divided into two groups. The first driver group did not use telematics-enabled devices, the other one did. The former was further divided into individuals who were guided by their experience and habits and did not alternate their route and those who often would take the risk to change the route because of current road situation. For the second group, it was considered whether the satellite navigation could operate in a perfect manner i.e. the system is able to plan and compute the actual quickest possible route.

3.1 Analysis of the decision making process

The decision about the route is determined above all by assessment of road and weather conditions. They were divided into three groups:

- Favourable - little traffic, good atmospheric conditions,
- Average - traffic density typical for given route, moderate weather conditions,
- Difficult - high traffic volumes, disruptions expected due to accidents, moderate or bad weather conditions.

The driver makes the assessment every time before setting off and has an influence on when the journey starts. As far as the first group of drivers is concerned, the assessment is based on weather conditions and information about traffic situation provided by media (radio, TV, internet). Having departed, those drivers relied solely on their own assessment of road conditions. Regarding drivers using an electronic support system e.g. ATIS (Advanced Traveller Information Services) the route and route assessment were provided by the telematics system and was updated en route. Both the drivers using telematics and those who did not, made their own decision about setting off based on information they gathered.

3.2 Research results

Results of the experiment were illustrated in table 1. Initially it was noted, that the group using an electronic support system made a more informed decision about commencing the journey. It was also established, that the group exposed to the biggest risk of delay was the one not using telematics-enabled devices and it also often made the decision to change the route. Average delay in that group was as high as 36 minutes. In case of drivers abstaining from telematics solutions with full awareness, who planned the route based on their experiences averaged a delay of 13 minutes. The drivers using telematics-enabled devices receiving a live feed about traffic situation were exposed to lowest risk of delay, because based on that information, computer systems and routing algorithms were computing the quickest route. Average delay of drivers using ATIS was 7 minutes, whereas the probability of reaching destination before projected arrival time was 0.92. In contrast, the "aggressive" drivers had a 0.78 chance of arriving in time.

Such driver`s experiences with using telematic systems could incentivise greater trust towards those solutions and consequently facilitate managing the traffic, where ITS systems were used. On the other hand, it is worth bearing in mind that trust could be quickly depleted should the systems fail to produce expected benefits to the drivers.

Tab. 1. Travel time form Laurel to Dale City (USA) [8]

Commuter	On-Time Reliability	Lateness Risk	Early Schedule Delay (ESD)		Late Schedule Delay (LSD)		In-Vehicle Travel Time	Trip Distance
			Average Monthly ESD	Maximum Observed ESD	Average Monthly LSD	Maximum Observed LSD		
	[%]	[%]	[h]	[min]	[min]	[min]	[min]	[km]
Conservative Non-User	90	10	2.8	43	13	28	62.1	80.8
Aggressive Non-User	78	22	1.4	29	36	43	63.1	80.8
ATIS User	92	8	1.6	32	7	19	62.2	81.2
Optimal Performance	100	0	0	0	0	0	61.3	80.8

4. Conclusion

This paper focused on man-machine communication which determines how in-vehicle telematics-enabled devices are designed and on impact those solutions have on travel planning and alternating it en route. Issues presented in the second chapter should be perceived as starting ground for further research. Experiences achieved in that fashion should stimulate further development of ITS communication interfaces coming standard on-board vehicles. Findings of the American research presented in third chapter give valuable, yet today somewhat out of date, grounds for accepting ITS solutions in Poland. It is especially important just prior to introducing in Poland the National Traffic Management System (KSZR) which is about to go on-line in 2014. It is planned to be integrated with CCTV surveillance of road surface and variable message signs informing about road situation and free parking spaces. It is important that at the preliminary stage, KSZR creators conduct a broad-based research into technological as well as psychological aspects of influence the newly-built system will have had on the drivers.

An additional incentive to start researching impact of telematics-enabled devices is a EU directive stipulating that from 2015 going forward, every car in EU has to be equipped with eCall automated emergency call for road accidents.

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