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# Analysis of factors affecting driver's distraction by the new types of HMI in vehicles

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**ABSTRACT**
The article presents an analysis of modern on-board HMI in vehicles due to their potential ability to induce distraction while driving. The first part of the article introduces the current stage of knowledge in the design trends on-board HMI devices. The next section contains a review of existing researches in the field of driver's distraction and comparison with other factors that affect safety. The second part of the article presents an analysis of the results of survey conducted among drivers. The study aimed to gain knowledge of the drivers opinion about modern on-board HMI interfaces. The article concludes with a summary and conclusion.

**KEYWORDS: applied ergonomics, HMI, driver's distraction**

## 1. Introduction

Contemporary transport depends increasingly on efficient communication systems [12]. ICT systems employed to improve transport processes are classified as Intelligent Transportation Systems (ITS) [14]. In Directive 2010/40/EU (7 July 2010) [4] ITS is defined as systems in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management but in fact ITS may refer to all modes of transport. The aim of ITS acc. to [4] is to improve performance in the field of transport mobility, ecology and safety. The key importance in ITS system is an efficient integration of an advanced telecommunication technologies and an advance of electronic equipment within transport infrastructure and in the vehicle.

The technologies integration in ITS system allows to access many different sources of live information for vehicle users, passengers, and infrastructure managers. Achieving the goals of ITS involves upgrading the road infrastructure and vehicles. For several years we have seen more and more advanced on-board equipment to enable wider access to advanced information while driving. Nowadays, designing an automotive product such as a car or a truck involves the integration of many technologies according to requirements of different force groups (e.g. customers, business, manufacturing and regulators) and trade-offs between requirements of different systems in the vehicle. On the other hand on-board systems in the vehicle should not only function well, but they must also satisfy the customers and be safe. The field of applied ergonomics or human factors engineering in the automotive product development involves assuring all important ergonomic requirements and issues relevant to the needs of users i.e. drivers (including workers) and passengers.

Unfortunately, the introduction of telematics on-board systems has an impact on the behavior of drivers while driving. This change in behavior occurs as a result of human–machine interaction. The interaction is made via the user interface or human–machine interface (HMI) which is the part of the machine (here vehicle) that handles the human–machine interaction.

The HMI, in the terminology of industrial design field [3][9] is the space where interactions between humans and machines occur. The goal of this interaction is to allow effective operation and control of the machine from the human end, whilst the machine simultaneously feeds back information that aids the drivers' decision making process.

The rest of this article will present the current state of knowledge on the development of on-board HMI, analysis of factors affecting the dispersion of the driver and the survey results.

# 2. HMI in a vehicles

Today's driver has an access to information from many kind of different sources in a vehicle (e.g. speedometer, fuel gauge, warning sounds, warning lights, radio display, symbols, etc.) and can interact via many activators (e.g. pedals, a steering wheel, buttons, turns stalks, etc.) to control the movement of the vehicle and/or change the states of different in-vehicle devices but today more and more often the driver interacts with a touch screen integrated telematics system or fewer with an audio system.

## 2.1. Visual HMI

The control and display buttons are the interface between the human operator (the driver) and the machine (vehicle). In nowadays car the human–machine interface is typically computerized and is made as a display panel or a touch screen [15].

The touch screen display has a control surface overlaying the display and are operated by finger touch without any existing buttons or gauges. The touch areas are displayed visually, and they act as control buttons. The touch screen controls are a more direct form of control interface than any other physical controls in the vehicles.

It should be noted that about ten years ago, screens were used only in luxury vehicles. Drivers of other cars could retrofit their cars with additional unincorporated solutions, such as PNA (Personal Navigation Assistant). In recent years, we can meet more often build-in the touch screen display as a part of a vehicle on-board equipment. In exchange for the buttons and knobs we have one or more touch screens. They display advanced information about the status of in-vehicle systems, the road navigation status or other information useful during the travel.

The figure 1 illustrates an example of nowadays visual HMI interface in the interior of the car.

**Fig. 1. Interior of Citroen C4 Picasso and it's HMI [own study]**

## 2.2. Audio HMI

Audio interfaces are in addition to visual interfaces. Until recently, the scope of the information was very limited. It included tone acoustic signals indicating the door open, not wearing seat belts, warning about the state of operation of the vehicle. Typical car-audio system was intended to provide an entertainment and has been only marginally integrated into the vehicle and its information systems.

In recent years, the acoustic on-board interfaces are more often complex and allow to transmit information in the form of a voice messages [16]. Advanced HMI audio system allows to interact with the driver and executing his orders. This is possible through the use of technology TTS (*Text-To-Speech*) and VR (*Voice Recognition*). The VR technology allows to create a feedback communication channel by which it is possible to issue understandable to machine voice commands. These technologies helped to introduce to the on-board HMI well known in telecommunications systems technology as IVR (*Interactive Voice Response*). In telecommunication IVR allows clients to interact with a company services without participation of the office workers. The communication is via a host system by use of a telephone keypad or by speech recognition, after which the system can serve their own inquiries by following the IVR dialogue. In automotive vehicle industry IVR allows to communicate with the driver in similar way as man to man by engage TTS and VR technologies.

The MMI based on IVR technology can be very convenient to handle some tasks for example indicate a new route with satellite system, control some functions of the automation in a vehicle (e.g.: launching wiper, adjusting temperature, sliding windows), the management of mobile voice communication as well as to activate emergency systems.

Some investigators [16] engaged in the development of the audio HMI see this type of communication as a way to reduce the degree of driver distraction and improve the accessibility to information coming from telematics systems.

# 3. Driver's distraction

On-board HMI is a constant source of information. The driver is able to access to the information through their own actions, but can be indicated by the system. If the transfer of driver's attention takes too long time it can lead to safety hazard [2].

Distraction is defined as the process of diverting the attention of an individual or group from the desired area of focus and thereby blocking or diminishing the reception of desired information. In theory, cognitive psychology [7] human shows five aspects of attention, which in fact relate to the functioning of a man with too many simultaneously occurring stimuli. These are: the selection of sources of information, the ability to search the perceptual field, prolonged concentration, divisibility of attention and shifting attention. When the driver is delayed in the recognition of information needed to safety accomplish the driving task, it occurs because of an event, activity object or person within or outside the vehicle compelled or tended to induce the shifting attention away from the driving task.

Distractions come from both external and internal sources. External distractions include factors such as visual triggers, social interaction, music, text messages, and phone calls. There are many studies describing the use of mobile phone while driving and its influence on the driver [6,10,13,18]. There are also internal distractions such as hunger, fatigue, illness, worrying, and daydreaming [12,19]. Both external and internal distractions contribute to the driving safety.

The statistical studies contain many examples of accidents caused directly by the distraction of a driver. Among the most frequently mentioned causes of distraction [8] are:

- talking on a cell phone (either a handheld or a hands-free device),
- dialing a cell phone or other handheld device (includes the use of shortcut keys),
- reaching for a cell phone (includes locating and answering),
- reaching for an inanimate object inside the vehicle,
- sending text messages or using the Internet to read e-mail or Web content,
- adjusting the radio, HVAC (*Heating, Ventilation, Air Conditioning*) or other internal vehicle system with controls on the dashboard,
- adjusting controls other than those for the radio or HVAC (e.g., windows, seat belt, rearview mirror, or sun visor),
- looking at a roadside object (e.g., a previous crash or highway incident, a construction zone, a pedestrian, an animal, or other known or unknown object),
- eating (with or without utensils),
- drinking a nonalcoholic beverage from an open container with or without a lid, straw, or both.

## 3.1. Results of distraction

The way of distraction caused by the on-board HMI used while driving can be very different and can be dangerous. In general, the driver can be under:

- the physical distraction which may occur when the driver has to use one or both hands to manipulate the HMI include a hand-free telephone dial panel, answer or end a call or text message, changing radio tune, air condition system or new direction in the navigation system
- the visual distraction which is a result of a too long period of time look out of the road. When the drivers' eyes are on the HMI or other thing for example mobile phone for the period two or more seconds [18], his or her visual attention is away from the road and it lead to hazardous situation.
- the auditory distraction as a result of the driver initiation or hanging up the phone call or by the conversation itself. Another reason may be an unexpected signal from the HMI which is not clearly indicating the cause of the alarm.
- the cognitive distraction which involves lapses in attention and judgment. It occurs when two mental tasks are performed at the same time. Focus on reading HMI alert competes with the demands of driving. Listening, alone, can reduce activity in the part of the brain associated with driving by more than a third.

As the results of performed studies show [17], the driver's reaction times are 30 % slower when telephoning while driving than driving under an alcohol with BAC levels of 80 mg/100 ml and 50% slower than under normal driving conditions. When the driver is making a phone call while driving his or her reaction time is longer to traffic signals or other relevant traffic events. The probability of missing important traffic signals is also increased. Another studies acc. to [5] show that braking reaction time is reduced during an in-car telephone conversation by between 0.3 to approximately 0.7 seconds and drivers brake harder with shorter stopping distances.

Studies have proven a significant drop in situation awareness in perception, comprehension and projection of other traffic due to the level of concentration demanded by the in-car telephone phone conversations. While the driver use a mobile phone, he or she accepts shorter gaps between cars, makes fewer speed adjustments and adjusts less to potentially dangerous road conditions. In addition to this some researchers observed that the drivers engage in risk compensatory behavior while using the mobile phone and reduce speed or increase headways to offset any perceived potential danger.

Some researches [1,10] indicate that the use of hands-free and handheld phones produce the similar impairment in performance compared to normal driving without using a phone. This is due to the fact that modern HMI and mobile phones are more sophisticated to operate and require more attention than before.

## 3.2. Mitigation of driver distraction caused by HMI

The problem of driver distraction as a result of HMI interruption is regarded as a problem of human–machine interface design. One of the proposals to solve this problem is to use the windscreen as the interface to display the information. It is a technology known from the military aviation called HUD (*Head-Up Display*). An example of presents figure 2.


**Fig. 2. Example HUD HMI in a vehicle [own study]**

According to the multiple resource theory of attention [20], humans only have limited amounts of attention available at any given time and different tasks using the same attention resources leads to distraction. Distraction from the primary task, i.e. driving the vehicle, can reduce driver safety by degrading the vehicle control (speed maintenance, lane keeping, etc.) and an object or event detection [18]. Based on this knowledge some researchers e.g. [16] explore alternative methods of communication to overload visual channel. They suggest auditory, tactile or even olfactory capabilities of the human sensual system as a new channel of communication with driver.

# 4. Survey research

In response to the challenges described above, the author of this study conducted at the end of 2015 a survey to assess interest in new technologies by Polish drivers and a preliminary assessment of the phenomenon of distraction. The research was conducted on a group of 30 drivers (10 women, 20 men) declaring possession of driving licenses. Drivers are divided into three age groups:

a. below 25 years old – 8 respondents,
b. 26 – 50 years old – 17 respondents,
c. drivers over 51 years old – 5 respondents.

Most of respondents (67%) declared a decade of experience in driving, and nearly 40% more than twenty years of experience. All test responders were asked to fill out a questionnaire on their age, sex, driving experiences, hearing and sight disabilities.

## 4.1. The results of drivers' experience with HMI

The main part of the survey concerns the current drivers' experience with visual interfaces. The first question concerned the knowledge and use of satellite navigation system GPS. The device is chosen as a representative of present and future HMI. The next question concerned the frequency of use of such a system. 90% of the surveyed drivers declared use of this device. Among them, about 83% said that most often use of the system by selecting a new, unknown destination. Another question was related to the type of GPS device. The choice was given four options: built-in vehicle, PNA (Personal Navigation Assistant), Smartphone / Tablet, the other device. The results of answers shown in figure 3.

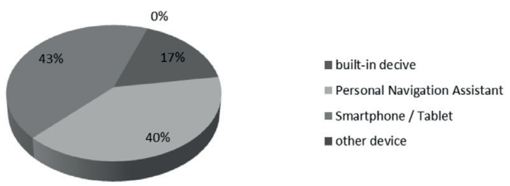


**Fig. 3. Types of HMI used by drivers as the navigation system [own study]**

In response to this question it was found that an increased number of drivers has built such devices in their vehicles. The largest group are the drivers who use the smartphone as the navigation system. This shows that the trend in drivers' preferences have been changing.

The next question asked of drivers concerned the experience with the distraction occurred as a result of interaction with the GPS device. Several possible answers were suggested to this question, but they were given the opportunity to write their own.

Among other causes of distraction, the first was an incoming call on the phone or text message. Another interesting experience was a disparity between the map and a voice prompt or the repetition of the same message when the driver chose a different path the one suggested by the GPS.

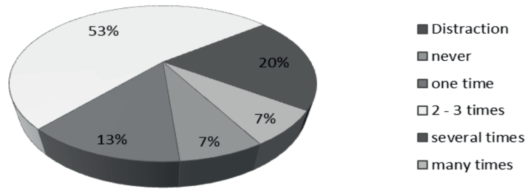


**Fig. 4. Drivers' opinion of HMI distraction [own study]**

## 4.2. Preferences and expectations of future HMI

Furthermore, the study tried to determine the degree of acceptance of new solutions to assist the driver in the vehicle. In general, three-quarters of respondents accept the new information and communication technologies in vehicles. At the same time, more than 86 % of the respondents declared that they are interested in receiving the information while driving about the current state of traffic on a route and 67 % of drivers information about current weather conditions and the state of the road surface.

Respondents were offered four possible answers to the question related to methods of informing while driving. They were the lights in the dashboard of the vehicle, HUD, voice messages and acoustic signals. The question permit a multiple choice. The results of the reply to this question is shown in Figure 5.

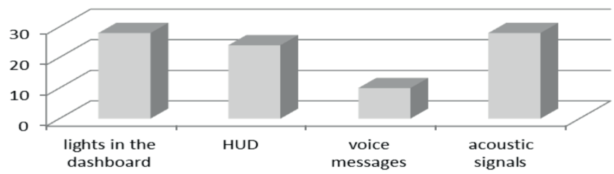


**Fig. 5. Drivers' preferences of way of communication on-board systems [own study]**

The surveyed persons were also asked a question about the preferred methods of operating these devices in vehicles. To choose presents four options: keyboard (keys), touch screen, voice commands, and other. The results of this study are summarized in the chart below.

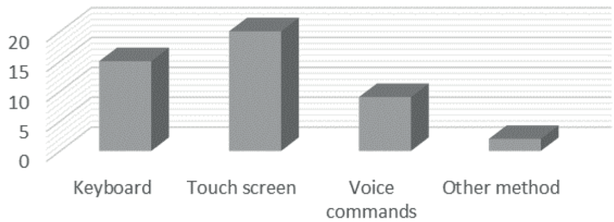


**Fig. 6. Drivers' preferences of method of operating with on-board systems [own study]**

An interesting fact is that despite the enormous popularization of touch screen interfaces, still a large number of drivers prefer use of a hardware buttons. Voice communication is treated as a marginal and imprecise in the command control and communication.

# 5. Conclusion

The conducted study confirmed strong interest in driver assistance and information systems in vehicles. The development of ICT brought the popularization and dissemination of built-in vehicle HMI touch screens as the well as satellite navigation systems (GPS). A large part of the respondents expect a reliable information on the route comes the satellite navigation system. Drivers having such information feel more confident starting new route and they can more consciously respond to current traffic problems. However, respondents confirm negative effect of modern HMI in vehicles. As a result, drivers focus on the device and its interface instead of the road scene. In this regard another research should be performed to assess ergonomic aspects of such interfaces. Especially dangerous seems to be the lack of consistency between visualization and voice information. Among the causes of distraction surveys also served the frequency of occurring alerts and their "aggressiveness". Another cause of distraction is an unexpected event that causes the shift the driver's attention. The most common cause of such events is using a common interface to handle phone calls and text messages (including an e-mail).

The final part of the survey questions have arisen about the expectations of drivers associated with HMIs. The survey shows that a large number of them are interested in innovations in the field of visualization, however skeptical towards the possibility of voice communication. This is an opportunity for new technologies to allow an improvement of man - machine communication but it is also a challenge for designers in the field of ergonomics on-board vehicles.

# Bibliography


[1] BROSTRÖM R., BENGTSSON P., AXELSSON J.: Correlation between safety assessments in the driver car interaction design process. Applied Ergonomics vol. 42, pp. 575 – 582, 2011.

[2] BIRRELL S.A., YOUNG M.S.: The impact of smart driving aids on driving performance and driver distraction. Transportation Research Part F, vol. 14, pp. 484 – 493, 2011.

[3] DANIELSSON L., et al.: HMI Principles for Lateral Safe Applications. C. Stephanidis (Ed.): Universal Access in HCI, Part II, HCII 2007, LNCS 4555, pp. 330–338, 2007.

[4] EU, Directive 2010/40/EU of 7 July 2010 - on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport.

[5] Jeanne Breen Consulting: Car telephone use and road safety. Final Report. An overview prepared for the European Commission http://ec.europa.eu/transport/road_safety/pdf/car_telephone_use_and_road_safety.pdf, 2009.

[6] MCEVOY, S.P., et al.: Role of mobile phones in motor vehicle crashes resulting in hospital attendance: A case crossover study. British Medical Journal, 331, 428–433, 2005.

[7] NĘCKA E., ORZECHOWSKI J., SZYMURA B.: Psychologia poznawcza. PWN 2013.

[8] KLAUER S.G., et al.: Distracted Driving and Risk of Road Crashes among Novice and Experienced Drivers. PMC (2014). http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4183154/

[9] KRAMER A.F., WIEGMANN D.A., KIRLIK A.: Attention: From Theory to Practice: From Theory to Practice. Series in Human-Technology Interaction. Oxford University Press. USA, 2006.

[10] KWON S., LEE D., CHUNG M.K.: Effect of key size and activation area on the performance of a regional error correction method in a touch-screen QWERTY keyboard. International Journal of Industrial Ergonomics vol. 39, pp. 888-893, 2009.

[11] PERZYŃSKI T., LEWIŃSKI A., ŁUKASIK Z.: The Concept of Emergency Notification System for Inland Navigation". Information, Communication and Environment. Ed. Adam Weintrit & Tomasz Neuman. CRC Press Taylor & Francis Group, London 2015.

[12] PETTITT, M.A., BURNETT, G., STEVENS, A.: Defining driver distraction. In: Proceedings of World Congress on Intelligent Transport Systems, San Francisco, USA 2005.

[13] Praca zespołowa pod kierunkiem: Dąbrowska-Loranc M., Wojszo T.: Korzystanie z telefonów komórkowych przez kierujących pojazdami w Polsce w 2014 roku. Ministerstwo Infrastruktury i Rozwoju Sekretariat Krajowej Rady Bezpieczeństwa Ruchu Drogowego. Warszawa, 2014.

[14] ROSIŃSKI A.: Modelling the maintenance process of transport telematics systems. Publishing House Warsaw University of Technology, Warsaw, 2015.

[15] ROSS T., BURNETT G.: Evaluating the human}machine interface to vehicle navigation systems as an example of ubiquitous computing. Int. J. Human-Computer Studies vol. 55, pp. 661-674, 2001.

[16] SODNIKA J., et al.: A user study of auditory versus visual interfaces for use while driving. International Journal of Human-Computer Studies. Elsevier 2007.

[17] STRAYER D., DREWS F., CROUCH D.: A Comparison of the Cell Phone Driver and the Drunk Driver. Human Factors, Vol. 48, No. 2, pp. 381–391, 2006.

[18] TIJERINA, L.: Issues in the evaluation of driver distraction associated with in-vehicle information and telecommunications systems 2000. From: /http://www-nrd.nhtsa.dot.gov/departments/nrd-13/driver-distraction/PDF/3.PDF, [date of access: 12.12.2015].

[19] U.S. Department of Transportation NHTSA: Distracted Driving 2013. Summary of Statistical Findings. DOT HS 812 132. NHTSA's National Center for Statistics and Analysis. http://www.distraction.gov/downloads/pdfs/Distracted_Driving_2013_Research_note.pdf, [date of access: 12.12.2015].

[20] WICKENS, C.D. In: Parasuraman, R., Davies, R. (Eds.), Processing Resources in Attention. Varieties of Attention. Academy Press, New York, USA, pp. 63–102, 1984.


 