Methods of Physical and Mental Testing of Vehicle Drivers and Its Role in Road Traffic Safety Improvement

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Safety in the road traffic is largely dependent on the physical and mental condition of the driver. Current research as well as the analyses conducted on certain phenomena-psycho-physiological efficiency of drivers, their skills, the influence of extrinsic factors on drivers, the technical parameters of vehicles and finally the distracting power of the environment - all prove that it is achievable to minimize risk in the road traffic.
There are various testing techniques, some of them are directed at the driver (eye tracking, heart rate and breath gauging or neuro-imaging), other techniques test the on-board car systems and still others test the visual and radar monitoring of the environment outside the vehicle. All of these techniques, for one thing enable tracing the driver's actions and for another, provide information about the processes which affect the driving person.
It should be noted that, owing to the above mentioned study, new knowledge is being developed. Both the research conducted with modern equipment, such as the systems of visual and radar analysis of the driver's surrounding area, and the systems which gauge psychophysical condition of the person, even if they might not ensure our totally comprehensive grasp of the safety processes in transport, yet they provide new and valuable information which is expected to facilitate our understanding of the role and influence of psychophysical processes in a driver on safety in the road traffic.
Data collected with such methods will enhance our knowledge with details that have been unknown so far. Besides, the methods will let us perceive the phenomena which may, for that matter, serve to verify current theories or even lay the foundations for totally innovative knowledge that may help to analyse the influence of the driver's psychophysical condition on the road traffic safety.
What is more, the resultant knowledge may be further employed to work out effective tools for aiding safety to different means of transport in motion. The development of tools and methods which are supposed to enhance and ensure safety in the road transport is the clue issue being tackled by both domestic institutions and the European Union.
For a few years now, safety in the road traffic in developed countries has been one of the essential issues regularly discussed and studied.
The aim of this article is to present both the testing methods as well as the role of psychophysical condition of the driver on safety in the road traffic.

Keywords: safety in the road transport, the driver, techniques of psychophysical testing, simulator.

1. INTRODUCTION

Undoubtedly, all road users should be guaranteed safety. Road traffic safety includes two important aspects, namely the sense of no fear and the sense of confidence. Road traffic safety has become a significant element of the social and transport policy of the European Europe and Poland. This is the response to the risk which increases following the dynamic development of the road transport. The present paper focuses on the issue of safety in the road traffic. The present authors discuss the role of psychophysical condition of the driver in the process of causing and averting dangerous road events. Some methods of psychophysical testing of drivers are brought to notice. They should be widely applied in practice in order to counteract risk and to improve road safety.

Methods: Literature on the subject is analysed to unfold the problem. Furthermore, essential EU

and Polish documents are cited to help discuss the issue of safety from the political perspective. The analysis of the testing methods is made on the grounds of literature, the instances of research conducted by specialised institutions and finally, following the available statistics in the field of safety.

Aim: The aim of this paper is to present first, the testing methods and second, the role of psychophysical condition of the driver in the process of the road safety improvement.

Conclusions: The problem of the road safety requires special treatment for the obvious reason that there is a tendency for the road transport to expand. New training and testing methods for drivers are indispensable. For one thing, such methods would prepare drivers-to-be to drive a road vehicle, and for another, they would eliminate the basic risks and danger coming from the driver. Undoubtedly, the advancement of electronic systems to keep the driver's psychophysical condition monitored is becoming a necessity. What is more, the incorporation of simulators in testing drivers, owing to their feature of recurrence and safety, should become a common practice. Technological development of such methods is the modern tool which may aid lowering risk factors on the one hand, and lay foundations for new legal standards in safety, on the other.

2. SAFETY IN THE ROAD TRAFFIC – A POLITICAL ASPECT

Transport requires full coordination of the, so far, dispersed databases of safety and databases of the safety level monitoring. As for the monitoring, it is a tool that provides education for the people involved in the transportation system. Then, it markedly contributes both to the investigation of the causes of road accidents and to the avoidance of unnecessary risk in transportation. The integrated way of looking into the causes of accidents in transportation is essential for preventive actions; a good illustration being a new tendency in the European Union, based on the so called "European methodology of research into the safety of accidents in the transport sector".[1] The issue of safety in the road transport gained significance in the 2001 EU White Paper "European transport policy for 2010 – time to decide"[2].

As for the issue of safety it may be understood in a variety of ways. According to Stanczyk[3], safety is reflected by the ability to survive and the possibility of development, but also by independence, identity and certain stability of existence. In Wicher[4], safety is considered from the perspective of methodological and systematic analysis of risk in the relation: a man – technique – environment. Such analysis aims at the elimination, management or lowering, down to a tolerable level, of the frequency of the occurrence of unwanted events. Still another point of view on safety is presented by Krystek[5] who understands safety in more general terms as the state of being free from risks, but also as the freedom of action without the sense of risk. Legal regulations are established in order to ensure safety through the elimination of the existing risks as well as the causes of their appearance.

Safety in the transport system comprises the following elements: the origin of risks, the diagnosis of the safety system condition, the mission and aims of safety-oriented actions, the programme of preventive steps, the application of safety improving measures, then, the monitoring of the on-going actions and finally, the evaluation of their efficiency.[6] Road transport, from the road traffic perspective, is the most dangerous branch of transport which carries the highest social costs, and which is, at the same time, the most common mode of transportation. The term road traffic is understood as the flow of vehicles and pedestrians on roads. Road traffic safety includes, among others, the supervision and organization of the road

[1] Zukowska J.: Integrated system of safety in transport – synthesis, Chapter 3, Diagnosis of the state of safety in the Polish transport , WKIL (Transport and Communication Publishers), Warsaw 2010, p. 16.

[2] White Paper – European Transport Policy for 2010 – time to decide, University of Szczecin, Szczecin 2002, pp. 108 – 115.

[3] Stanczyk J.: Contemporary meaning of safety, PWN (Polish Scientific Publishers), Warsaw 1996.

[4] Wicher J.: Safety of automobiles and the road traffic, PWN (Polish Scientific Publishers), Warsaw 2004 p. 32.

[5] Krystek R. (ed.): Integrated system of safety in transport vol. 1, Integrated system of safety in transport in Poland, Diagnosis of safety in transport in Poland, WKIL (Transport and Communication Publishers), Warsaw 2009 p. 352.

[6] See: Krystek R. (ed.): Integrated system of safety in transport vol. 3 Concept of Integrated system of safety in Poland, WKIL (Transport and Communication Publishers), Warsaw 2010.

traffic, the training and examining of future drivers, the psychology of transport, the technical condition of vehicles, signposting, the technical condition of roads and highways, medical rescue, and last but not least, propagation of proper behaviour among road traffic users.[7]The occurrence of adverse consequences of badly designed and mismanaged transportation system has recently led to the evolution in the approach to the issue of safety in the road transport in Europe. The European Parliament, the European Commission and the European Conference of Ministers of Transport (ECMT) unanimously agree that the Union citizens' right to move freely is inseparable from their right to safety, therefore, the task to ensure safety for all the transport system users should gain a top priority. In fact, road accidents account for about 95 % of all transport accidents. In accordance with the guidelines of the European Road Safety Action Programme 2011-2020, declared by the European Commission, and the Global Plan for the Decade of Action for Road Traffic Safety 2011-2020,declared by the UN General Assembly, the European Commission directs (in its Communique to the European Parliament on "Road traffic safety policy for 2011-2020")[8] to undertake the following:

- establishment of a structured and coherent cooperation framework which draws on the best practices across the Member States, as a necessary condition to implement, in an effective manner, the road safety policy 2011-2020;
- adoption of strategy for injuries and first aid to address the urgent need to reduce the number of road injuries;
- devising the safety programme for especially vulnerable road users, such as motorcyclists, for whom accidents statistics are particularly worrying.

Quantitative objectives of the Programme for the EU Road Traffic Safety for 2011-2020 are, among others, 40 % fewer fatalities and 60 % fewer child fatalities from 0-14 years of age. The main risks for the road traffic safety, as the programme shows, arise from excessive speed, alcohol and drug abuse, unfastened seat belts and the lack of proper vehicle equipment for children, upgrading the road infrastructure and fitting the vehicles with intelligent systems. There is a new action philosophy lying behind the EU transport policy, namely, "Safety culture philosophy". This philosophy is substantiated by the on-going analyses of the road traffic safety which show that disasters and accidents are not at all mostly caused by a particular failure of the transport subsystem. Such events result most of all from the instances of human negligence either in the maintenance and regular control of the vehicle units and devices or in the work discipline. The stages for the establishment of the culture of safety is presented in chart 1. European Commission, in 2011 White Paper[9], outlined the strategy for the establishment of a single European transport area to express aspiration for the achievement of the competitive and resource-efficient system of transport. The document predicts the following steps to carry out the vision zero road traffic safety project which, in other words, aims to achieve a system with no fatalities or serious injuries in the road traffic:

- Harmonise and deploy road safety technology[10] – such as driver assistance systems, (smart) speed limiters, seat-belt reminders, eCall, cooperative systems and vehicle-infrastructure EN 22 EN interfaces – as well as improved road worthiness tests which include, among others, alternative propulsion systems;
- Focus on training and education of all users; promote the use of safety equipment (seatbelts, protective clothes, anti-tampering).

[7] Wicher J.: Safety … op.cit. p. 32.

[8] Communication from the Commission to the European Parliament, TheCouncil, The European Economic and Social Committee and the Committee of the Regions - Towards a European road safety area: policy orientations on road safety 2011-2020, pp. 2-3.

[9] White Paper, Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, Brussels, 28 March 2011, COM (2011) 144 final version, p. 25.

[10] cf.Grochowski W. Modern technologies for road transport, UBIK BC, Warsaw 2009, p. 41 et seq.

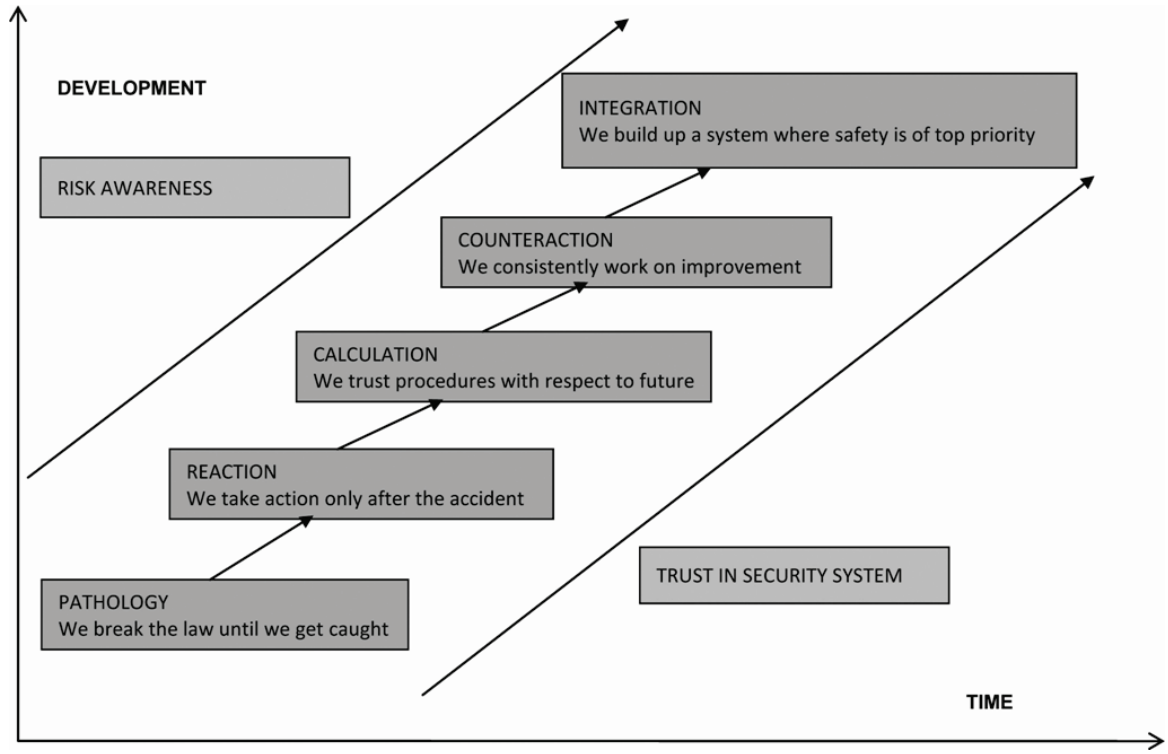


Chart 1. Stages for the establishment of road traffic safety culture.
Source: R. Krystek, Road traffic safety in Poland on the eve of new transport policy of the European Union, Gdansk University of Technology, Department of Highway Engineering, presentation at International Seminar Gambit, 2010.

The significance of the safety issue in the transport policy is reflected in the statistics for the road risks (number of casualties / 1 million of people) in the EU countries in 2011-2012. These figures indicate that the average for member states dropped to fewer than 60 casualties per 1 million people in 2012. As for Poland, this number also decreased to the level below 100 casualties per 1 million people in the same time. Nevertheless, out of 28 countries surveyed, Poland is the fifth from the end.[11] Altogether there are 1.3 million casualties a year in transport. The total cost borne by the European Union amounts to € 200 billion; the same cost for Poland reaches PLN 30 billion.[12] The problem of the road traffic safety has become a serious global problem. In 2010 it was presented as "The world global crisis in the road traffic safety" at the UN General Assembly. This problem, by its very nature, has now been adopting political dimension, especially when fast development of the road transport is taken into consideration. Chart 2 presents the forecast for the passenger and freight transport growth rate for 2000-2050, as prepared in 2011 by the International Transport Forum, established by OECD member states. The benchmark was set up as 100 for the amount of transport in 2000. The forecast assumes substantial increase of passenger-kilometres in the passenger transport and ton-kilometres in the freight transport in 2000-2050. Poland has also registered increased road traffic, by over 20 %in 2005-2010. Such data give additional impetus to finally tackle the problem of the road traffic safety. Here, Poland effectively contributes with its programmes and institutions to the EU transport policy. One need only mention ZEUS (Integrated System of Transport Safety) and Road Traffic Safety Observatories (according to Safety NET).

[11] cf. Fatalities by population. Evolution 2011-2012, Road Safety Vademecum. Road safety trends, statistic and challenges in the UE 2011-2012.
[12] cf. KrystekR.(ed.): Integrated system of transport safety vol. 3, Concept of integrated safety system in Poland. WKIL (Transport and Communication Publishers), Warsaw 2010 (as cited in the World Bank).

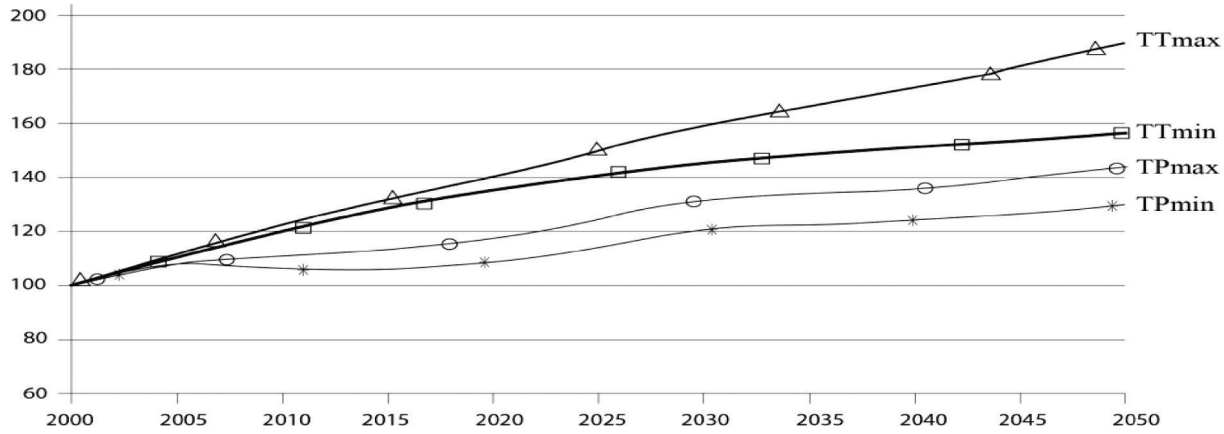


Chart 2. Forecast for the passenger and freight transport growth rate in 2000-2050 (TTmax – maximum freight transport, TTmin – minimum freight transport, TPmax – maximum passenger transport, TPmin – minimum passenger transport).
Source: Road traffic safety in Poland with particular reference to heavy goods vehicles, Road and Bridge Research Institute, Leszek Rafalski, www.not.org.pl/not/files/2012/bezpieczenstwo-transport/prezentacje/11.pdf

3. SELECTED ASPECTS OF THE ROAD TRAFFIC SAFETY IN POLAND

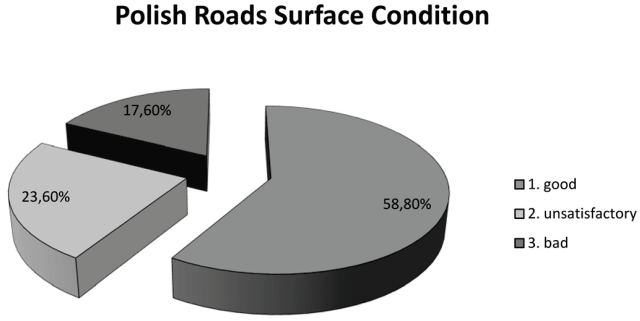
Road accidents are not really perceived as a burning problem in Poland. Institutional efficiency results from the adopted principle of shared, collective responsibility for the road traffic safety management problems. [13] In Poland, despite still relatively low motorization index, the life and health risk for the road user is high. The following are the main causes of such situation: low driving culture and common disrespect for traffic regulations (particularly those for speed limits, drunk driving, the obligation to use protective devices), but also low quality of roads infrastructure and low, albeit increasing (owing to Road Traffic Inspection) efficiency of traffic supervision.[14] Between 2002 and 2012 over 51 thousand people died and 590 thousand more were injured in road accidents. On the basis of available data, one can see that for 100 road accidents in Poland, there are about 11 casualties, 31 people are seriously injured, and 93 more sustain moderate or light injuries.[15] Death risk on Polish roads is twice higher than EU average, and the Polish share of 14 % in the total number of fatalities is striking, especially when juxtaposed with the ratio of 8 % of the Polish population within the European community. In recent years Poland has implemented safety improving measures such as the obligation for drivers and passengers to have seat-belts fastened and to always drive with the headlights on low beam. Among the most recent steps is the installation of numerous photo-cameras. These actions have brought positive effect, in particular 15 % lower deaths rate in 2012 in comparison to 2011.[16] Actions for improved road traffic safety have been a priority within "zero vision". The idea of zero vision in security policy was initiated in Holland and then developed in Sweden. The latter has managed to decrease the rate of fatalities from 25 % to 35 %.[17] New, 2011 European Transport Policy adopted Zero Vision – 2050 which should be understood as no road accidents by the year 2050.[18] The so called "Polish Zero Vision" means the following: human life and health above all; these values are put ahead of mobility and other aims of the transport system. This further means that we all should have the

[13] National Programme for Road Traffic Safety 2013-2020, KRBRD, 2013.
[14] Aksamitowska I.:Role of Road Traffic Inspection in the process of increasing road traffic safety, unpublished paper, Pultusk Academy of Humanities 2013.
[15] National Road Traffic Safety Programme 2013 – 2020, Plenary paper at KRBRD (National Council for Road Traffic Safety), Warsaw 2013, p. 5.
[16] Based on www.europa.eu/index_fr.htm
[17] cf. Krystek R. (ed.): Integrated system of transport safety" vol. 3, Concept of integrated safety system in Poland, Transport and Communication Publishers, Warsaw 2010 p. 23.
[18] White Paper, Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, Brussels, 28 March 2011, COM (2011) 144 final version.

sense of responsibility for road accidents and for the elimination of their fallout. Additionally, road systems and vehicles should be designed, constructed and exploited in a way to allow minimization and compensation of traffic users' errors. Finally, all procedures of the traffic and transport management system should care for the safety of its participants. In order to pursue such vision there is a necessity to foster the awareness of the road traffic participants so that, at the end of such education, we have road users who will respect both the law and other road users' rights. Among educational, preventive and coercive measures, the top priority must be applied to three actions; first -aiming at the reduction of instances of speeding, second – aiming at the increase in the number of people wearing seat-belts and third – focused on eradication of the instances of intoxication by road users. These three offences - speeding, no seat-belts and intoxication - account for over a half of road accidents resulting in deaths in Poland. Road infrastructure, then, is blamed for direct or indirect cause of 30 % of road collisions. Road parameters directly affect the road traffic users' behaviour and the proper design of the particular elements of the road infrastructure potentially leads to decreased number of road casualties. The condition of the Polish road infrastructure is presented in chart 3. The development of safe and structured network of roads and streets as well as advanced way of the road traffic management significantly contribute to improved conditions for safe road traffic. The requirement for any project of a road network solution (new or modernized road) to undergo the assessment that will check its impact on the road traffic safety, is sine qua non for the elimination of road risks. National Programme for the Road Traffic Safety is the fundamental document which underlies the implementation of all the enterprises to lower the road transport system risks. Besides that, it also determines the scope of the system and sector operations from the central level. This National Programme for the Road Traffic Safety 2013 – 2020 outlines the following areas where actions must be taken in order to improve safety on the roads:

- safe behaviour of road traffic users
- safe road infrastructure
- safe vehicles
- effective rescue system and medical assistance

Lines of action correspondent to each of the above areas will involve engineering, monitoring and education.[19]



Condition	[km]	[%]
good	10 871	58,8 %
unsatisfactory	4 365	23,6 %
bad	3 256	17,6 %
Total	18 492	100,0 %

Chart 3. Assessment of the technical condition of the surfaces of national roads in Poland at the end of 2011. Source: Report on technical condition of Polish national roads at the end of 2011. Prepared by: Department of Diagnostic Systems for Road Network, Warsaw, March 2012, p. 5.

Safety in the road transport is a multidisciplinary issue and it lies within the fields of interest of many institutions at the central level, apart from the Minister of Transport. Such other institutions that get involved in the road traffic safety are, e.g., Ministry of Interior, local self-government organizations, social and non-government organizations. The present authors hold the view that the coordinated system, sector and regional actions, subject to sufficient funding, will effect in much improved safety on the Polish roads. Transport safety policy is presented in the Strategy for Transport Development by 2020 (with the outlook for the years by 2030) – Safety in Transport.[20] The said document outlines the

[19] Strategy for Transport Development by 2020 (with the outlook for the years by 2030), Ministry of Transport, Construction and Maritime Economy, Warsaw 22 January 2013, p. 7, Condition of the road traffic safety, actions taken in 2009 and recommendations for 2010, Report, National Council for Road Traffic Safety, Warsaw, March 2010.

[20] Strategy for Transport Development by 2020 (with the outlook for the years by 2030), Ministry of Transport, Construction and Maritime Economy, Warsaw 22 January 2013.

schedule of transport development in the nearest future. The following needs for innovative solutions in transport have been particularly emphasized in the Strategy: management and monitoring of transport infrastructure, traffic management, the use of cutting-edge technologies of materials and systems which will decrease pollution generated by transport. According to the premises of the Strategy for Transport Development, new solutions for transport will:

- facilitate integration of individual branches of transport and positively affect traffic optimization and infrastructure management;
- effect in better information service for transport services recipients which will translate into improved safety of traffic users;
- reduce the adverse effects of transport on the environment and climate; enhance its energetic efficiency and alleviate negative effects of climate change which affect the infrastructure and transportation itself; contribute to better safety of traffic participants;
- make use of Intelligent Transport Systems whose potential for implementation lies within the road transport area – from the toll collection, through the systems that give support to the road traffic management and safety, to the comprehensive, common information for the travellers.

There are three factors which influence the number and effects of road accidents: the man, the vehicle and the road. Out of these three, it is the man that remains the main perpetrator. Apart from objective factors, which relate to the condition of the infrastructure, a number of reasons for excessive rate of accidents derive from the traffic organization and the road transport users' behaviour. A group of people who most often join the road traffic and, because of that, are highly exposed to road accidents are professional drivers. Due to this reason, this professional group is the subject of particular interest of both scientists and the institutions which are in charge of the road traffic safety. The latter seek factors which account for the occurrence of road accidents because their right diagnosis and the identification of causes will lead to more effective prevention of risk and improved road traffic safety.

4. ROAD VEHICLE DRIVER AND ROAD TRAFFIC SAFETY

A professional driver is either a person who, for a payment, renders road transportation services and transports people or freight, or, a person who is licensed to drive an engine vehicle. Drivers are not only exposed to road accident risk. They also face up to inconvenient weather conditions and physical danger such as noise, vibrations, high and low temperatures or hazardous substances. Additionally, factors such as the system of "just in time" supplies, long driving hours, the lack of sleep, inadequate breaks, insufficient rest between shifts, solitude and separation from the family and friends are typical for the road transport sector.[21] According to the European Agency for Safety and Health at Work (EU-OSHA)[22] a lot of road accidents can be prevented through the analysis of the situation in the haulage company, the identification and assessment of risk and finally, the practical steps in order to implement means by which the risk is avoided or reduced at the very root. Such principles should be applied to the process of devising and implementation of the plan for safety and health management on roads, the plan which would concern vehicles and their equipment, planned operations and the personnel. The elements of the plan are shown in table 1. Work in the road transport sector requires high skills and professional qualifications. Road vehicle drivers, who cover long distances, must be able not only to drive, but also to load and unload their vehicle, to solve technical problems; they must have some linguistic competence and know the basics of administrative issues, the last but not least, they act in the capacity of their companies' ambassadors in other countries.

[21] www.osha.europa.eu/pl/sector/road_transport/index_html

[22] www.osha.europa.eu/pl/sector/road_transport/index_html, Ibid.

Table 1. **Occupational safety and health issues to cover in a management plan.**

▪ Road risk while driving ▪ Appropriateness of vehicle and maintenance ▪ Driver competence, training and medical fitness ▪ Journey planning ▪ Prolonged sitting and constrained postures ▪ Workplace design (cab) ▪ Air conditioning, lighting, noise ▪ Manual handling while loading, unloading ▪ Vibrations ▪ Mechanical impact (struck by moving or falling objects/vehicles) ▪ Biological agents ▪ Hazardous substances ▪ Fire and explosion hazard	• Hazards from transported animals • Exposure to cold in refrigerated lorries • Slips and trips • Falls from the cab or trailer • High workload or pressure of time • Low organising scope • Shift-working or exchanging working schedules • Violence • Lone working away from a fixed base (includes obstacles to communication and participation in OSH) • Welfare facilities (rest, eating, washing facilities) • Aging workforce, adaptation of conditions to women workers, cross-border working • Stress from hazards listed above • Cooperation with others (clients, sub-contractors, where goods are collected form or delivered to)

Report by EU-OSHA comprises all transport sectors and highlights types of typical hazards and risks to road transport drivers. These findings are presented in table 2 below:

Subsector	Some issues highlighted
Public passenger transport	▪ Violence and harassment ▪ Increased customer contact, incl. translating organisational changes to customers, incl. at ticket counters ▪ Lone work ▪ Shift work ▪ Conflicting demands (attending customers and driving), leading to high blood pressure and cardiovascular diseases ▪ Needs of an ageing workforce
Taxi services	▪ Violence and assault, lack of reporting systems and training ▪ Lone work ▪ Working time and shift work issues ▪ Workplace design ▪ Having to use communication means while driving
Long-distance road haulage	▪ Just-in time management leading to high work pressure ▪ Client pressures; working on sites of others ▪ Increasing use of remote monitoring and complex technology
	▪ Workplace design ▪ Accessibility of facilities and services (hygienic, food and medical) ▪ Infectious diseases ▪ Violence and assault ▪ Lone work ▪ Prolonged sitting and exposure to vibration ▪ Accident risks, incl. when loading and unloading ▪ Needs of an ageing workforce
Dangerous goods transport	▪ Accident risks, incl. fire and explosion risks ▪ Exposure to dangerous substances, especially when loading and unloading ▪ Risks of falls from vehicles and other transport means
Courier services	▪ Unforeseeable conditions at customers´ premises, e.g. availability of safe lifting aids ▪ Customer expectations and contact ▪ Accident risks and climatic conditions, e.g. for bicycle couriers ▪ Lifting and handling parcels/goods of unforeseeable sizes and shapes ▪ Work organisational issues – work pressure due to short-term changes in tasks, use of remote monitoring/contact systems (drivers receive orders while driving)
All	The specific combination of risks and combination of factors such as ergonomic risks, work organisational stressors, noise, dangerous substances, vibration, unusual working times, working away from home and from a work base, lack of facilities, complex work situation, the need for constant adaptation, and the many structural changes that have occurred in the sector are a particular challenge for monitoring and prevention.

Source: www.osha.europa.eu/pl/sector/road_transport/index_html

The above analyses highlight, for one thing, the role of transport drivers and the need to invest in them, and for another, working conditions in the road transport. More and more legal requirements are added to the process of gaining driving qualifications, for instance those referring to the driver's working hours.[23] Among the causes of the driver's errors, most frequent are the following: alcohol and recklessness, microclimate conditions, work time and tiredness, distraction, brainwave, insufficient skills. Institute of Vocational Illnesses

[23] cf. Starkowski D., Bienczak K., Zwierzycki W. Domestic and international road transport. Compendium of practical knowledge. Drivers' work environment. Logistics Vol.III Poznan 2010 p. 414.

in Lodz has carried out neurological tests on drivers who were involved in road accidents. The tests results lead to the conclusion that, repeatedly, functional or physical abnormalities in the patient's nervous system may have substantial influence on the occurrence and course of accidents. [24] Dangerous driving errors are usually made in case of a sudden change of the situation on the road. These could be, for that matter, time deficiency or high volume of traffic and the necessity for the driver to decide whether to complete the task on time and, at the same time, to violate the road regulations. In order to face up to such inconveniences, the driver needs certain personality features which, in emergency cases, will guarantee the maximum of his reliability. This reliability also means that such a driver's risk of taking a wrong decision or making a mistake is minimal. The following features make up for a reliable driver: knowledge, experience and driving skills, but also personality, cognition efficiency and psycho-physical agility.[25] Psychophysical condition is of paramount importance for a driver in traffic. However, as yet this issue has been studied the least. In Poland, driving simulators, which, nota bene, truly imitate genuine driving conditions, are not fully taken advantage of either in the recruitment of drivers or in the training processes. Considering this inconvenience, comprehensive psychophysical study of drivers in real-like simulated conditions is yet to be conducted. Attempts made so far, both in Poland and abroad, to apply driving simulators to testing drivers have only focused on selected psychological functions. Advanced EU countries have already done such research. Initially, pilots' psychophysical condition was tested on flight simulators. The effects were fundamental for the recruitment and selection of applicants - potential pilots as well as for the increased flight safety. Following that success, research programmes were extended on other professions, such as railway engine drivers and underground train drivers, and, also the drivers of buses, heavy-duty vehicles and special-duty vehicles (e.g. heavy fire and rescue vehicle). Data presented in Baks[26] indicate that most psychophysical functions which are vital for efficient driving, may be subject to temporary, age-related changes and to gradual deterioration which comes with age. These data are further confirmed by law regulations which oblige drivers over 60 to undergo psychological testing more frequently. In fact, 2001 Act on Road Transport imposes the duty to undergo psychological tests every 5 years on drivers below the age of 60, and every 30 months when they turn 60.[27] Contemporary trends and policy towards defining psychophysical condition of drivers is common in many countries in the world, e.g.: Holland and Great Britain, where obligatory testing was introduced in order to confirm whether people in certain age groups are still capable of safe driving. The problem of safety and minimizing the risk of road incidents is closely related to the predisposition of drivers.

5. METHODS OF TESTING PHYSICAL AND MENTAL CONDITION OF DRIVERS

The level of physical and mental agility in drivers is the elementary factor conditioning safety in the road traffic. During drivers' work, a variety of factors appear to influence either in a direct or indirect way their behaviour on the road. Among the methods which test physical and mental condition of drivers are the ones which monitor and experiment or simulate, methods which assess the influence of the surroundings and finally, the methods which assess the risk.

5.1. DISCOVERY AND OPPORTUNITY

Physical and mental agility of the driver is subject to testing. The driver's behaviour and emotional condition are tested. The results of such testing help to evaluate the driver's effectiveness at work. The model for the evaluation of the physical and mental efficiency of a driver is presented in chart 6. The concept of the monitoring system for checking the driver's physical and mental condition assumes the use of, among others, the following applications:

- simulator equipped with the driver's cabin
- software with the visualized natural environment

[24] cf. Wagrowska-Koski E.: Harmful and onerous work environment and the resulting health hazards to engine drivers, IMP (Jofer Institute of Occupational Medicine), Lodz 2007.

[25] cf. Luczak A., Najmiec A.: Tests on psychophysical condition of accident and non-accident drivers from the perspective of accidents prevention and increased road transport culture of safety, CIOP (Central Institute for Labour Protection), Warsaw 2009.

[26] cf. Bak-Gajda D., Bak J.: Psychology of transport and road traffic safety, DifinWarswa 2010.

[27] Act on Road Transport,Dz. U. [Journal of Laws] from 2001, No. 125, item 874 as amended.

- software to create different scenarios of the surroundings, external conditions or dangerous situations which carry a variety of reactions of the road traffic users
- medical equipment to record all significant physical and mental parameters of the tested driver, such as, e.g. heartbeat (ECG)
- psychological methods to test intellectual efficiency
- software to enable recording the course of every simulator - conducted test, e.g. the course of the drive, physical and mental parameters, automatic evaluation of the results and their archiving.

Such integration of the system allows to solve the three elementary problems:

1. Safe and efficient simulator – based training of drivers, to aid their psychological and physiological testing, on the basis of reproduced variety of driver's work environment as well as real-life driving conditions of a heavy-duty road vehicle;
2. Proper qualification for the driving profession owing to the simulator-based tests which help to verify the accuracy of psychological tests and to decide on the most suitable method for testing physical and mental efficiency of drivers. This is of great significance from the perspective of driver's accident prevention.

- Opens the door to the study of the driver's related factors, the factors which determine safe driving and to their categorisation (e.g. microclimatic conditions, medicines, etc). Thorough knowledge of how these factors act, both individually and in different configurations, makes it plausible for researchers to develop the methods to counteract the adverse effects of these factors, and, by the same token, to minimise road traffic risks.

5.2. EXPERIMENTAL RESEARCH AND SIMULATION TESTS

Practical diversity and dynamics of situational changes on the road calls for psychological testing of the driver and his or her practical skills in action, i.e. while driving a vehicle. Here is where experimental research and simulation tests come in. Experimental research is conducted either in static laboratory environment or in a dynamic environment. The latter may be done while a person is driving a vehicle in the real road traffic or on the car testing track. Altogether, such research enables the analysis of the driver's behaviour in the face of real life road situations. Obviously, the situations and road traffic system elements used in the research are of diversified

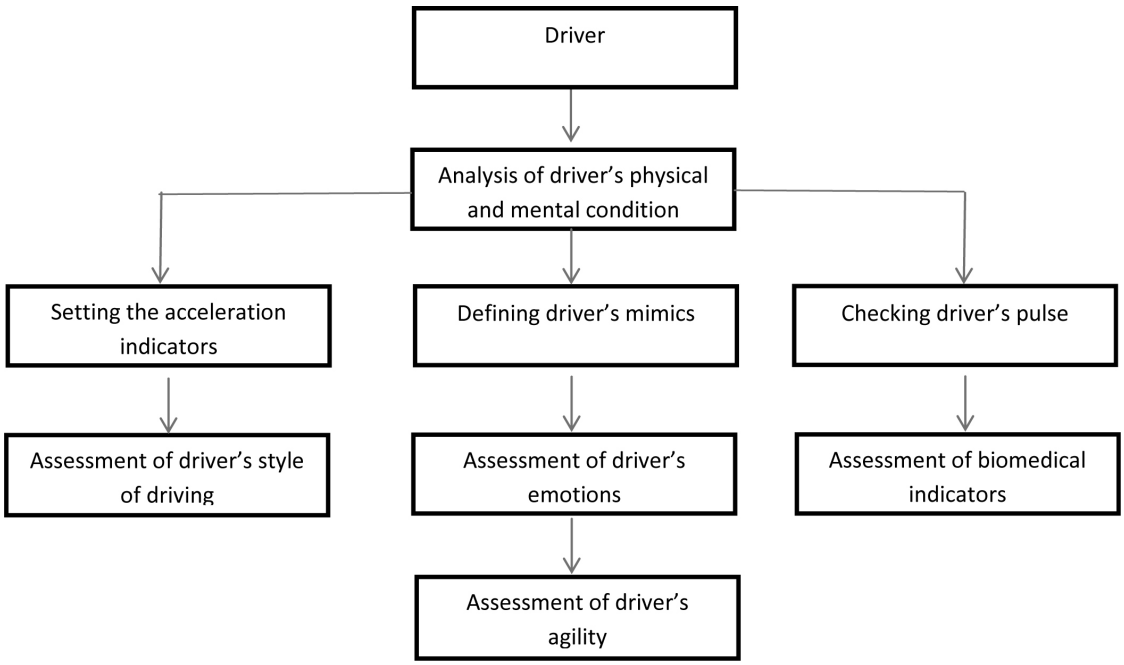


Chart 6. Block diagram model for the driver's agility assessment.
Source: A. W. Mitas, Z. Czapla, M. Bugdol, A. Rygula: Recording and evaluation of the driver's biometric parameters for the sake of road traffic safety improvement, Research Bulletin of the Silesian University of Technology, Transport, Gliwice 2010.

levels of difficulty. Simulation testing, conducted in simulators in different conditions of the road traffic, allows the testers to predict the behaviour and actions of the driver during his or her real life driving. Moreover such testing will show key factors tempting the driver to take up risk.

The driver's actions, when analysed from the dynamic perspective, characterizes with the three main processes:

- perception of information which serves as the basis for the driver to realize the situation on the road, i.e. the position and movement of the car and his or her own body;
- decision making
- manipulation, i.e. work movements during intended actions.

According to the 2005 Regulation issued by the Minister of Health,[28]drivers' personality as well as their intellectual and psychomotor agility are subject to thorough psychological diagnostics. It employs the most modern research test tools such as

- Vienna Tests System[29] invented by the Austrian company Dr.Schuhfried GmbH (the world leader in computer-assisted diagnostics, exercises and psychological rehabilitation) and the University of Vienna;
- methods recommended by the Institute of Road Transport[30] in Warsaw to assess the speed of psychomotor reaction;
- tools which belong to the Platform of Psychological Tests and serve to measure, among others, personality traits, the level of experienced stress, intellectual powers, proneness to risk;
- apparatus and mobile measuring systems which serve to monitor and record the driver's performance as well as his or her physical and mental parameters during real-life driving; here, Flicker-Fusion apparatus is used which enables researchers to specify the tiredness level in the driver; in the simulated driving test then, highly advanced eye-tracking technology is used which records the driver's eyes movements.[31] Eye tracking analysis provides information on, among others, where the driver casts his or her eyes most often. This in turn leads researchers to the conclusion on the way and character of the driver's reasoning and problem solving or the level of tiredness;
- mobile system apparatus designed for on-going monitoring and gauging of physiological and environmental signals and parameters, e.g. VENTUS system designed to record ECG signals.

Research results which come from different modules and systems are subsequently processed on the basis of especially designed algorithms which allow to assess the operational capabilities of drivers. To this effect, a variety of analyses are used, e.g. statistical analysis which exploits the cutting-edge techniques for data exploration; another one is discrimination analysis which is applied in order to define the variables that most diversify drivers into groups and, still another one to analyse the driver's concentration. A complex practical example of the above presented testing methods is the on-going project "Integrated system to monitor the driver's physical and mental condition with a view to minimizing risk in road traffic" (POIG.01.03.01-10-085/09) conducted by Nofer Institute of Occupational Medicine in Lodz and the Military Institute of Aviation Medicine in Warsaw in cooperation with businesses such as e.g. QS Ltd, CorpoFlota Ltd and Quasar Electronics. The aim of the project is to establish the first Polish integrated system for testing and training drivers. The system is equipped with modelled vehicle driving position together with the standardized procedure for psychological and physiological testing of a driving person.[32]

[28] Minister of Health Regulation of 7 January 2004 on medical testing of drivers and applicants for the driving profession (Journal of Laws from 9 January 2004 as amended).

[29] Ucinska M., Niezgoda M.: New prospects for psychology of transport in diagnostics and research. Road Transport, ITS (Institute of Road Transport) 3/2012 pp. 17-31.

[30] cf. Ucinska M., Tokarczyk E.: Psychology of transport in ITS (Institute of Road Transport). Past – present – future, Road Transport, ITS 3/2012 pp. 33–51.

[31] Ucinska M., Niezgoda M.: New prospects …..op.cit. p. 27 et seq.

[32] cf. Roznowski K., Bernat M.: Preliminary research on the analysis of psychological and physiological parameters and biological signals (POIG.01.03.01-10-085/09. Integrated system for monitoring mental and physical condition of drivers with a view to minimizing risk in road traffic, WIML (Military Institute of Aviation Medicine) Warsaw 2011.

5.3. METHODS OF MEASURING THE INFLUENCE OF THE ROAD ENVIRONMENT ON SAFETY IN THE ROAD TRAFFIC

The fact is that professional drivers have to meet higher and higher expectations. What is more, there is ever growing risk connected with the unstoppable road traffic volume. All this means that in order to achieve the best possible results in research as well as in the drivers' training and qualifying process, the use of simulators is indispensable. The two most commonly used simulators are the motor car simulator and the lorry simulator which are located in the Institute of Road Transport (ITS).[33] The simulators are fitted with ultra-modern systems for recording all significant psycho-physiological parameters in tested drivers. Independently of medical tests carried out on drivers, the simulator allows testing and assessment of the drivers' practical skills and their behaviour in unexpected and dangerous situations, their stress and tiredness resistance in real life road traffic. Such testing is possible owing to the modules of the virtual environment software that ensures perceptual illusion in tested drivers and situational realism during simulated driving. The basic elements of the simulated environment are, e.g. three-dimensional data base of the terrain (diversified landscape with natural surface and infrastructure; full road infrastructure (diversity of roads and road surfaces, bridges, flyovers, tunnels, level crossings, etc.); time of the year and time of the day; weather conditions; three-dimensional moving objects (other vehicles, trains and pedestrians; active systems for traffic direction).

5.4. DYNAMIC METHOD FOR RISK ASSESSMENT IN ROAD TRAFFIC – DTRM MODEL

Identification of the key risk factors which affect safety makes a dynamic relation with the defined safe stability point (BPS) to which, in turn, is ascribed short-term and long-term changeability. This requires scrupulous description of the internal and external processes as well as the explanation of the identified, multilevel interrelationship among the main components of the model called the Dynamic Traffic Risk Model (DTRM). The model affects the level of static risk and the range of dynamic risk of collisions and road accidents. BPS is subject to simulation testing, with its potential for changing positions in multifactor and multidimensional space being taken into account. The multiplicity of factors influencing the position of BPS include such as, e.g. tiredness, stress, distraction, concentration problems, malaise, haste, etc. Longer perspective changes are subject to age and diseases which impair psychomotor and psycho-intellectual capacity of drivers. A road traffic accident is the outcome of the following risks: driver factors, vehicle factors, environmental factors. Within these three risk groups determinants of the dynamic components of DTRM are pursued. The following are the components of DTRM:

- Assessment model – the driver's capability of fast and accurate assessment of the road situation is analysed; in particular his or her skill to perceive the overall situation on the road as well as the driver's general level of visual perception. The model is based on Vienna Tests System.[34]
- Decision model – the driver's decision processes are analysed. This aspect of the driver's work is scrutinized by e.g. Filary[35] who ascertains that it is the driver's decisions that are the main cause of road incidents. These decisions consist in the driver's recognition and choice of safety margins with reference to the actual road and driving conditions.
- Driver's perception of action model – here, three types of the driver's errors are analysed. They derive from three sources, namely, bearings errors, decision errors and action errors. The model of error analysis extensively adds up to the main risk model DTRM because, following the official statistics and the police and insurance firms' records, the roads users themselves account for as many as 93 – 98 % of road incidents.[36]
- Model of the driver's behaviour in particular road – traffic conditions. Here, what is analysed is, among other things, perceptive and motor variables of the driver, including his or her psychomotor predispositions and skills, their individual mainspring of action which is largely personality – conditioned,

[33] Ucinska M., Niezgoda M.: New prospects ….. op. cit. pp. 26 – 27.

[34] Ucinska M., Niezgoda M.: New prospects ….. op. cit. p. 20 et seq.

[35] cf. Filary S.: Safety in global communication and transport, WSB (School of Banking), Poznan 2010

[36] Filary S.: Safety ….. ibid.

psychological traits as well as particular external factors which are beyond the driver's influence.

All groups of variables which constitute the content of individual component models of the main DTRM, i.e., signals and parameters of the assessment model, decision model, error model and behaviour model, must be considered in order to specify, for one thing, the interior processes the driver is subject to, and for another, the external processes which happen irrespective of the driver, and yet exert impact on the level of static and the range of dynamic risk of this driver's collision or road accident. Furthermore, such approach facilitates identification and explanation of multilevel dependencies among the main components of DTRM. DTRM directed at the driver's mental and physical capacity, allows precise identification of the causes for the increased number of accidents and the assessment of risk groups.

Research project by a team from the Military Institute of Aviation Medicine (WIML) on a pilot group of 25 men aged 25 – 45, with minimum 5 – year driving experience, conducted first in laboratory conditions and then in real road conditions of especially equipped mobile laboratory, show explicit differences in drivers' behaviour in these two extremely different environments.[37]

6. CONCLUSIONS

Both the level and the system of the road traffic safety require a lot of attention and, at the same time, impose the necessity to employ modern technologies to constitute one collection of methods and tools in order to ensure efficient, effective and secure driving. Drivers themselves must also have particular predispositions and be adequately prepared to drive so as not to cause risk on the road. Testing physical and mental condition of drivers with the use of modern electronic laboratory and simulation equipment leads to the prevention and reduction of road accidents.

[37] WIML internal materials as cited in Zielinski: Monitoring mental and physical condition of drivers as the tool to minimize risk in road traffic, unpublished paper, Pultusk Academy of Humanities 2013 pp. 77-85.

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