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# ENSURING OPERATORS-DRIVERS TRANSPORT OF AGRICULTURAL MACHINERY SAFETY IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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The number and severity of road traffic accidents in the Russian Federation is not reduced from year to year. It is established that one of the common causes of traffic accidents is sleep at the wheel, it is especially typical for operators-drivers of transport agricultural machinery. According to the experimental data were derived mathematical dependences of operator reaction time of the driver at the beginning and end of the work shift by his age, which proved that with increasing age operator reaction time in an emergency increases.

**Keywords:** injuries, vehicle, driver, agro-industrial complex, safety

## Introduction

The processes of globalization in the XXI century are more focused on the goals of sustainable development strategy adopted by the UN and most of the world community. Sustainable development is seen as a new type of development in which global civilization processes take secure forms. Accelerating globalization of sustainable development is not possible without an effective solution of socio-economic and environmental problems, minimizing their negative consequences, and without reducing the impact of accidents, injuries and fatalities.

Conducted thorough analysis of accidents showed that from year to year the agro-industrial complex of the Russian Federation becomes a leader in terms of fatal injuries in the context of the main economic activities. Annually from the total number of deaths in the agro-industrial complex more than 20 % make drivers of vehicles and in more than 60 % the accidents occurred as a result of injury road traffic accidents.

The main cause of accidents in the agro-industrial complex of the Russian Federation is hitting vehicles on workers having a share of 39.5%, as well as the impact of moving, rotating parts and pieces of equipment, machinery, tools, having a share of 30.3%, traffic accidents – 7.7 %, falling from moving vehicles – 5.6%, vehicles overturning – 4.6%, others – 2.3% (Shkrabak, Lukovnikov and Turgay, 2002).

It is deduced that the most traumatic profession in agro-industrial complex of the Russian Federation is a transport agricultural machinery operator-driver (Ovcharenko, 2007).

At present, the material and technical base of the agro-industrial complex of the Russian Federation is supplied with a complex modern fleet of vehicles, which in addition to the field (seasonal) road conditions, daily are essential road users of federal, state and city roads, running danger of getting into an accident.

## Material and methods

Every year in Russia in road traffic accidents perish about 30 thousand people, are injured about 260 thousand people (Traffic Police of Russia, 2014). More than ¼ of people died in road accidents are of the most active working age (25–40 years), which indicates serious socio-economic and demographic consequences of road accidents (Chuklinov, 2014).

Distribution of the number of accidents, fatalities and injured in the dynamics is shown in Figure 1.

For comparison things with injuries due to accidents abroad are no better. For example, in the United States each year, about 30 thousand people die due to road traffic accidents and more than 2 million are exposed to injuries leading to disability (NHTSA, 2014).

Figure 2 is a comparative analysis of fatalities in road accidents proportion in 10 years in some countries (OECD, 2014). The most dynamic reduction of accident victims showed Sweden, the United Kingdom and Germany, and by the end of the reported period, they came to the values of 28, 31, and 44, respectively. These countries could be called the most «favorable» by the level of fatalities.

Russia can be only compared with South Africa in the number of deaths in road accidents, although there are some positive aspects in the dynamics development, but the growth rate is so small that Russia can approach the level of developed countries only a few decades.

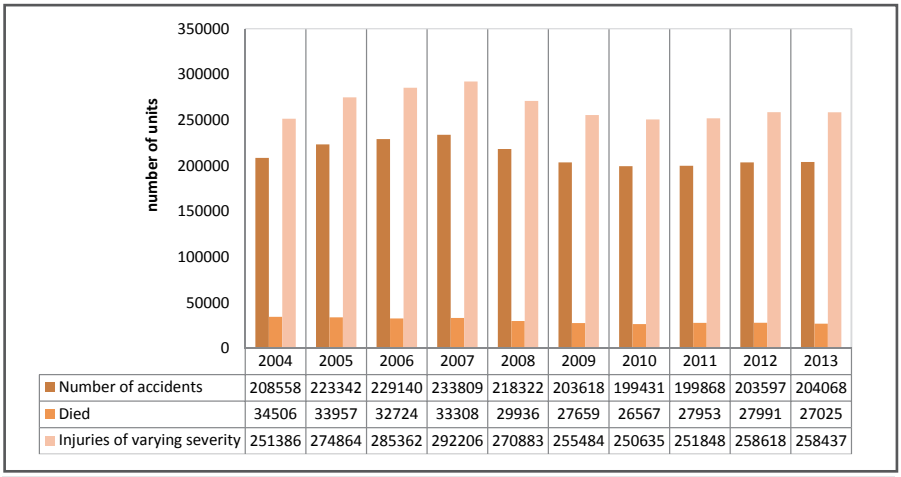
WHO predicts that road traffic injuries may become the third leading cause of death and injury by 2020, and more serious than such diseases as malaria, tuberculosis and AIDS (WHO, 2014).

In addition, the Russian Academy of Sciences data on the human factor in accidents importance coefficient $k_N$ in different areas of technosphere (Dobroborski, 2011) shown in Table 1 display that it's value for road transport is the second largest after military aircraft and, given the massive use of the vehicle, it can be affirmed that road transport is a major source of people death and injury.

**Table 1** Coefficient $k_N$ importance of the human factor

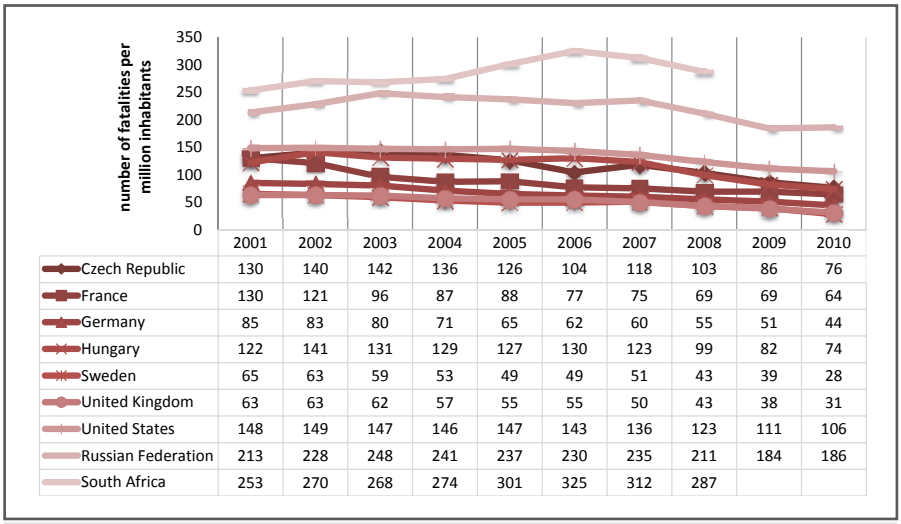
| No. | Areas of technosphere | $k_N$ |
|---|---|---|
| 1 | Nuclear energy | 0.55 |
| 2 | Industrial and civil construction | 0.7 |
| 3 | Rocket and space engineering | 0.35 |
| 4 | Military aviation | 0.85 |
| 5 | Civil aviation | 0.65 |
| 6 | Pipeline transportation | 0.3 |
| 7 | Automobile transport | 0.8 |
| 8 | Process equipment | 0.4 |

Source: Russian Academy of Sciences




| | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of accidents | 208558 | 223342 | 229140 | 233809 | 218322 | 203618 | 199431 | 199868 | 203597 | 204068 |
| Died | 34506 | 33957 | 32724 | 33308 | 29936 | 27659 | 26567 | 27953 | 27991 | 27025 |
| Injuries of varying severity | 251386 | 274864 | 285362 | 292206 | 270883 | 255484 | 250635 | 251848 | 258618 | 258437 |

**Figure 1** Dynamics of accidents in Russia in 2004–2013
Source: Traffic Police of the Russian Federation, own processing




| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Czech Republic | 130 | 140 | 142 | 136 | 126 | 104 | 118 | 103 | 86 | 76 |
| France | 130 | 121 | 96 | 87 | 88 | 77 | 75 | 69 | 69 | 64 |
| Germany | 85 | 83 | 80 | 71 | 65 | 62 | 60 | 55 | 51 | 44 |
| Hungary | 122 | 141 | 131 | 129 | 127 | 130 | 123 | 99 | 82 | 74 |
| Sweden | 65 | 63 | 59 | 53 | 49 | 49 | 51 | 43 | 39 | 28 |
| United Kingdom | 63 | 63 | 62 | 57 | 55 | 55 | 50 | 43 | 38 | 31 |
| United States | 148 | 149 | 147 | 146 | 147 | 143 | 136 | 123 | 111 | 106 |
| Russian Federation | 213 | 228 | 248 | 241 | 237 | 230 | 235 | 211 | 184 | 186 |
| South Africa | 253 | 270 | 268 | 274 | 301 | 325 | 312 | 287 | | |

**Figure 2** Trends in mortality as a result of road accidents in some countries
Source: Organization for Economic Co-operation and Development, own processing

By January 1, 2014 in Russia are registered more than 50.5 million units of vehicles by the traffic police. The main part of them – 76.7%, or 38.7 million units are passenger cars. The trucks fleet has increased by 22.9% and amounts more than 5.7 million units. Over the past 8 years, compared to 2004, the country's vehicle fleet grew by 44.2%, i.e. more than 15 million vehicles.

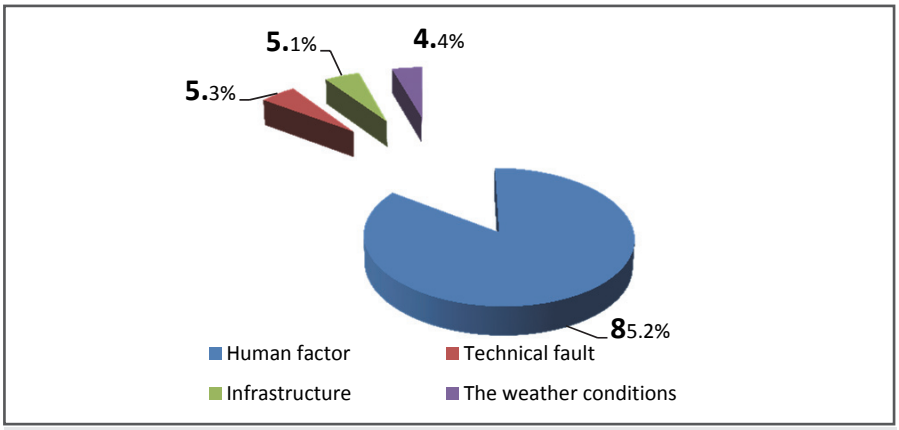



**Figure 3** Distribution of accidents main causes shares
Source: Traffic Police of the Russian Federation, own processing

The average annual transport growth makes up 5.5 % (Chuklinov, 2014).

Distribution of accidents main reasons is shown in Figure 3. It shows that the weather conditions were 4.4% of all accidents causes and the least significant one. The same small percentage of accidents refers to the vehicle technical failure (5.3%) and infrastructure (5.1%). The greatest number of accidents is caused by driver himself (85.2 %). This may be an accident because of driver's psycho physiological violations: deterioration in health status, accumulated fatigue, alcohol or drugs, traffic violations, as well as the distractions presence (conversations, conversations on the phone, distracting passenger).

Thus of 85.2% road accidents about 34% are caused by driver falling asleep while driving (Ovcharenko, 2007) – one of the most common causes of accidents. However, to prove the fact that the driver was asleep at the time of the accident is virtually impossible, so the official statistics of such cases does not exist.

Dreaming is a physiological need of a human organism. It consists of 5 stages – 4 stages of slow sleep (non REM) and a stage of rapid sleep (REM). A healthy person's sleep begins with the first stage of slow wave sleep (suspend, nap, somnolence), which takes 5–10 minutes (Danilova, 2005). Sleepy state doesn't reveal itself immediately. Initially drowsiness occurs, during which eyelids become «heavy», you want to close your eyes. Vision works, but the brain ceases to perceive visual information. While watching a person who is falling asleep, you will notice that his physical activity reduces. Movements rhythm gradually slows down, body muscles relax. In the sitting position the head leans on one side, and the items fall out from the hands. Breathing then becomes superficial and sustained. The number of breaths decreases from 16–18 per minute to 12–14 (Kupriyanovich, 1976).

Falling asleep while driving is a period of transition from wakefulness to the first stage of slow wave sleep and is caused by fatigue. The first stage is characterized by fatigue, loss of connection with the real world. A distinctive feature of fatigue – yawning – informs that the brain feels oxygen deficit. Eyes water, causing surrounding objects blur, sense of speed disappears. A driver trying to drive evenly slows down and then accelerates without noticing it. The late phase of fatigue is a strong desire to sleep. Neck muscles relax completely, the head no longer holds, eyes close by themselves.

Very dangerous is a short sleep with your eyes open. Waking up, the driver gets frightened,

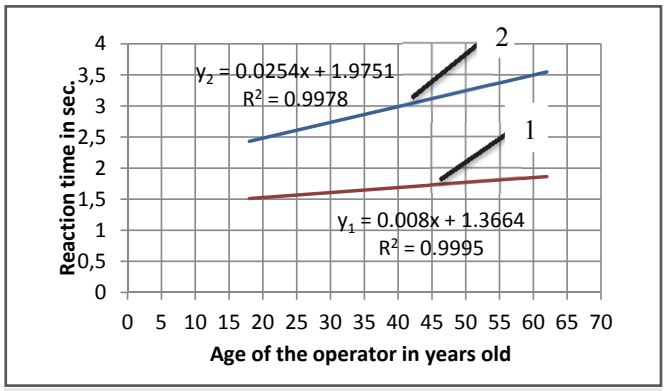



**Figure 4** The reaction time dependence of the operator (s) age (years) at the beginning and end of the work shift
Source: own processingg

heart rate increases, steering wheel slips out of hands. Often the driver does not immediately understand where he is and what he is doing, i.e. driver's reaction time is tens of times exceeds normal. It should be noted that in the city, where you always have to slow down and accelerated the vehicle it's harder to fall asleep, and vice versa on road straight sections (motorway, main road) the probability of sleeping significantly increases.

Experimental studies have found out that operators age sufficiently influence their fatigue index.

In accordance with the methodology and research program (Ovcharenko, 2007) experimental studies were carried out to determine the reaction time of the operator (*s*) on making the correct decision in emergency, depending on age at the beginning and end of the work shift.

As a result of variance and regression analysis of experimental data obtained by the regression equation shown in Figure 4: $y_1 = 0.008x + 1.3664$ with $R^2 = 0.9995$ (dependence 1), $y_2 = 0.0254x + 1.9751$ with $R^2 = 0.9978$ (relation 2) where $y_1$ and $y_2$ – the reaction time of the operator, respectively, at the beginning and end of the shift, in seconds, where x is the operator in years. Linear models tested on adequacy by Fisher and describe adequately the process under study.

From these graphs (Figure 4) one can see that with operators age increase his reaction in an emergency also increases. The difference in the reaction time at the beginning and end of the work shift increases regardless of age. Thus, in his twenties operator's time difference for his reaction at the beginning and end of shift is 0.9 sec, and in the retirement age of 60 years it is already 1.6 seconds, that is increased by 2 times. The reaction time increase is associated with operators' fatigue and can naturally lead to accidents and injuries (Ovcharenko, 2007).

## Results and discussion

In Russia there are a number of devices designed to reduce injuries associated with fatigue expressed in a possible operator falling asleep while driving agricultural equipment during the work shift. On such devices development at various times worked V. S. Shkrabak, M. S. Ovcharenko, V. A. Nebolsin, A. M. Loewenstein, V. V. Suhodoev and others. For example, an apparatus for motor control mechanisms in the event of drowsy or somnolence states was worked out (Patent no. 22877440 RF IPC B60K28/06). The principle of operation is based on comparison of the brain biopotentials of drowsy and active states with the delivery of the signal in the cockpit and automatic stop of the vehicle.

On the basis of in-depth analysis of existing devices which provide control of agricultural machinery transport operator's drowsy state, it follows that the device on par with the virtues has some significant drawbacks. A new device capable to react to the initial phase of sleep, i.e. on the phase between wakefulness and non REM sleep first phase is needed, as well as remote defining drowsiness.

Every year the number and severity of accidents increases. Accidents carry away more than one hundred lives and over 1,000 maimed every day. One common cause of accidents is driver falling asleep at the wheel. This issue requires further innovative ways search for effective solutions, ways and means of protection.

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