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NUMERIC TOOLS FOR TACHOGRAM ANALYSE

Summary. Paper describes numeric application supporting driving analysis process on attitude of tachogram data. Actual accessible units recording road and speed in function of the time were used. Also potential optimisation areas of driving were shown. Additionally in the paper are presented road safety level in Poland in the context of dangerous driver's behaviour.

NUMERYCZNE NARZĘDZIA DLA ANALIZY TACHOGRAMU

Streszczenie. Artykuł prezentuje aplikację numeryczną wspomagającą proces analizy zapisu jazdy kierowcy na podstawie tachogramu. Wykorzystano aktualnie dostępne urządzenia rejestrujące drogę i szybkość w funkcji czasu. Wskazano również potencjalne obszary optymalizacji przebiegu jazdy. Dodatkowo w pracy przedstawiono stan bezpieczeństwa na polskich drogach w kontekście niebezpiecznych zachowań kierowcy.

1. INTRODUCTION

The need of control driver's road behaviours came into along with the development of motorization, especially with the rapid increase in the number of vehicles. Driver's behaviour is the basic parameter, which determines road safety level. Widely understood safety is looked upon as a financial matter including compensation, repair or work break costs. However most of all road safety level affects human lives, which is priceless and irreplaceable.

Nowadays we posses a wide range of devices recording driving parameters, which could be useful in designation of individual driver characteristics. Information about average speed, time travelled or speed variability allows to describe driving style. Researches made by Tom Cherrett from the University of Southampton prove that: "Speed variability was found to be particular useful for identifying differences between individual driver's behaviour. Once differences in behaviour can be identified it may be possible to link certain driving habits to factors such as component wear, accident rates and excessive fuel usage". The paper is a continuation of researches described in work "The Computing Unit for Tachometer Data Analysis by Means of Driving Characteristics" [10].

Analysis and optimisation of driving characteristic must be preceded by the process of data assembling and monitoring. These activities have to be executed according to the introduced pattern:

Fig.1. Analysis and optimisation road drivers behaviour process
Rys.1. Proces analizy i optymalizacji zachowań kierowcy na drodze

2. DRIVER'S BEHAVIOURS

Road driver's behaviour illustrates aggressiveness level, which appear in the way of driving. Aggressiveness determines risk of occurring dangerous occurence, which directly lead to traffic accident. Police statistic shows that over 70% of accidents took place as a result of dangerous driver's behaviour.

In Poland in 2006 took place almost 46 thousand traffic accident, in which about 5 thousand people died and 69 thousand were injured. To the most common causes of traffic accidents we could distinguish:

- excessive speed in current conditions,
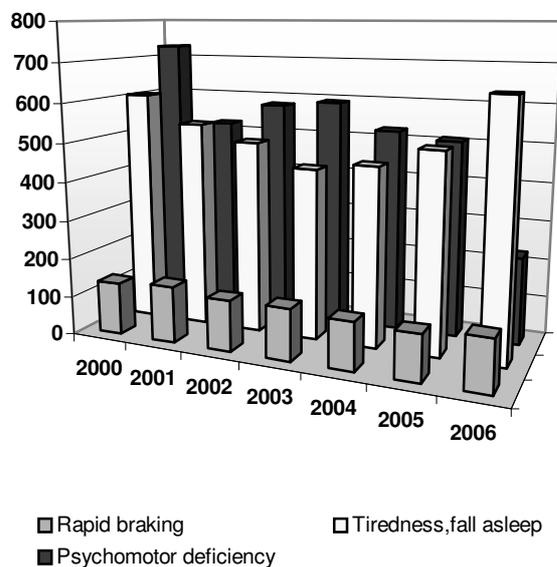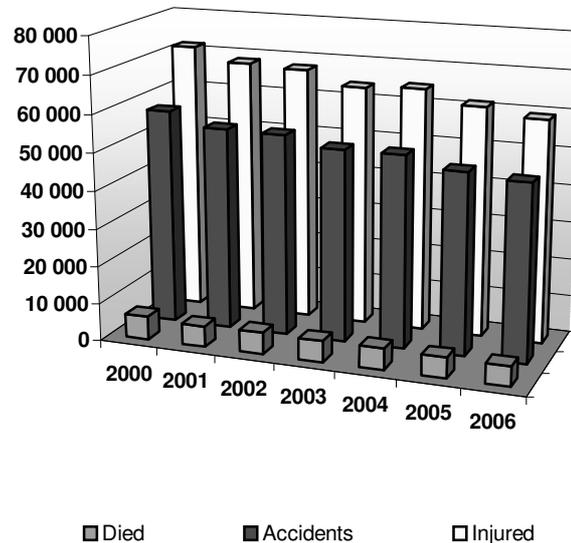- not giving way to a vehicle,
- not giving way to pedestrians.

Fig.2. Road accidents in Poland (Source: KGP)
Rys.2. Wypadki drogowe w Polsce (Źródło: KGP)

From the point of view of analysing driving characteristics,a significant part determine also events result directly from the psychophysics state of a driver:

- rapid braking,
- tiredness, falling asleep,
- psychomotor deficiency.

In 2006 from causes written above took place over 1 thousand traffic accidents, in which died about 140 people and 1,5 thousand were injured.

Fig.3. Road accidences result directly from psychophysical state of driver (Source: KGP)
Rys.3. Wypadki drogowe wynikające bezpośrednio ze stanu psychofizycznego kierowcy (Źródło: KGP)

Accidents results from psychophysical state of a driver could be predicted on the basis of driving style analysis. Taking note of accessible statistical material, which represent driving parameters justified the analysis of data registered by generally used tachograph units, installed in lorry vehicles. Heavy goods vehicles over 3,5 tonnes make 15 % of the overall number of vehicles on Polish roads.

Only in the first half of the year 2007 in Poland registered about 1,5 thousand traffic accidents caused by lorry vehicle drivers, in which died about 200 people and 2,5 thousand were injured. Excessive speed in the current conditions and not giving way were the main reasons for accidents with lorry vehicles. According to police statistics a significant part determining accidents resulting from driver's tiredness or falling asleep. A rough estimate in one of four, these type of events one person died. Statistically, the highest number of traffic accidents with heavy goods vehicle were registered on Fridays.

The written above information shows how important it is, respecting time norms and keeping the vehicles in a proper technical condition. Moreover, the essential part is also prevention and skilful recognition of occurring dangerous states through applying monitoring system and detecting fault of psychophysical efficiency.

3. MONITORING

Large group of devices, which combines the functions of a clock and a speedometer makes up the tachographs. According to the legal regulations in Poland, from the 1st of April 1999 every vehicle with allowable weight over 9 t, registered for the first time after 31st December 1984 and vehicles with allowable weight over 3,5 t, registered for the first time after 31st December 1999 must have a tachometer unit. The basic function of a tachograph is to register speed exceeding and required working periods of a professional driver. Two kinds of tachographs units are accessible in Poland:

Analogue units

Analogue tachographs are generally used from 1st April 1999. They record the vehicle's speed, driven on roads and the length of time. In use are two types of analoque units:

- Tachograph in the form of round speedometer.

    http://www.siemensvdo.com/products_solutions/commercial-vehicles/tachographs/analogue-tachographs/ktco-318-ec/KTCO-1318-%28EC%29.htm[*]

- Tachograph in the form of drawer, look similary like a car radio.

    http://www.siemensvdo.com/products_solutions/commercial-vehicles/tachographs/analogue-tachographs/mtco-1324/MTCO-1324.htm[*]

In analogue tachograph record of data is executed on round paper disc coated with wax substance by three or four scribers. Scribers move in line designated with disc ray, in distance depended on the recording data type. Group of scribers is mechanically related with clock unit, which rotate the disc.
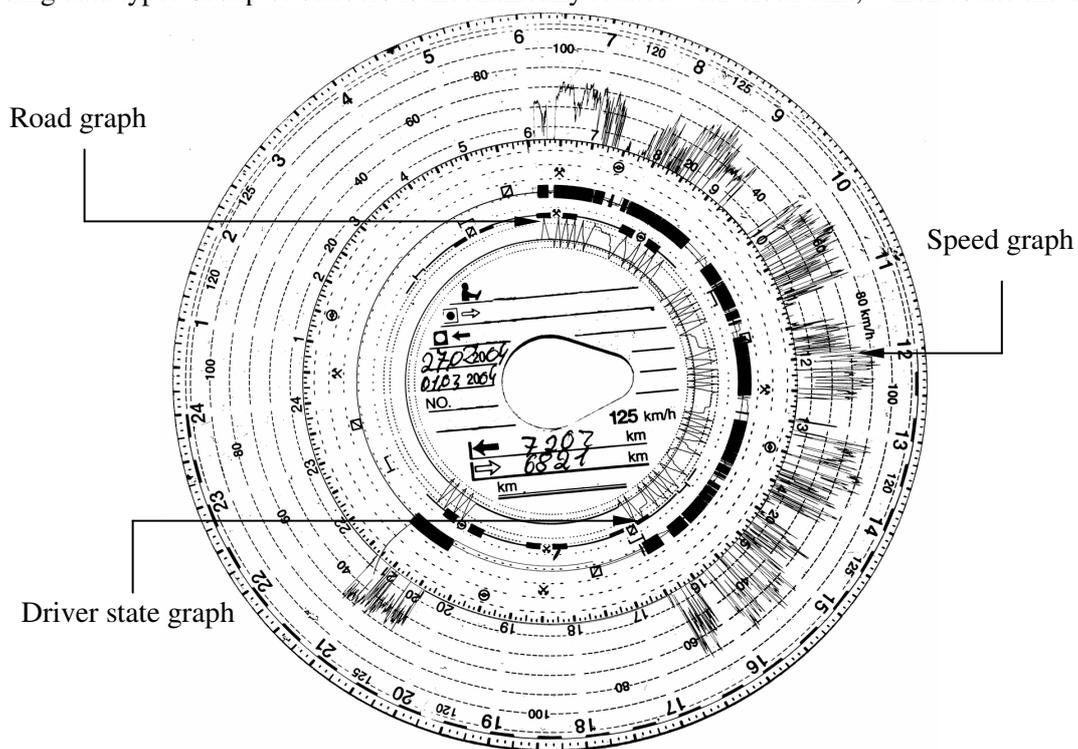
Fig.4. Example of the analogue tachograph disc
Rys.4. Przykład analogowej tarczy wykresowej

On tachograph disc we could distinguish following kinds of graphs:
- Speed graph –created as a result of up and down scriber movement when the car is accelerating or braking related with constant rotation of the disc.
- Road graph – regularly drew lines from up to down and vice versa on the circle. One line leaded to down or inversely means ride of 5 kilometres.

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* State on the day 07.12.2007

- Driver state graph – block record created with astragaloid lines. Width of the line determines driver's state of activity
  - ⊚ time of driving (the thickest line)   🖈 time of active work (thick line)
  - ☑ time of passive work (average line)   ⊢ rest time (thin line)

The disc has 123 mm diameter and executes one full turn in 24 hours. It means that in the time of one second the disc shift about 0,0045 millimetres on the outside edge, and 0,0029 millimetres on the inside edge of the speed graph. Change of speed for about 1 kilometre per hour causes vertical movement of the scriber for about 0,16 millimetres.

Analogue tachograph disc is an official document and has to be treated in a special way. The owners of transport companies have the duty to store all discs for the period of one year. All kinds of correction attempts are prohibited and will be recognised as a forgery, which is subject to imprisonment from 3 to 8 years.

Digital units

Digital tachographs secure greater reliability and resistance for a user in attempts to falsify. European Commission initiated the project of modern computer technologies utilization in the aim for recorded data safety and sanctity enlargement already in the latter 90's. Taking consideration of imperfection in using analogue tachographs, digital devices system was created. Such a system is less susceptible to users manipulations. Moreover, the possibility of easier and more effective control of working period by employers as well as supervisory organs was assumed. According to the 27th decree article (UE) no. 561/2006 vehicles registered for the first time after 1st May 2006 on terrain of European Union must to be equipped in digital tachograph. So far in Europe only three companies have got certification of approval:

- Siemens – digital tachograph DTCO 1381

  http://www.siemensvdo.com/products_solutions/commercial-vehicles/tachographs/digital-tachographs/dtco1381/DTCO-1381.htm[*]

- Actia – digital tachograph LS 2000

  http://www.actiapoltik.pl/?id=36&prod=22[*]

- Stoneridge – digital tachograph SE 5000

  http://www.stoneridgeelectronics.co.uk/digital_tacho_2.aspx[*]

Data are recording on the digital driver's card, which is also used to identify driver and secure selective access rights. Cards store data concerning every state during the drive and the break with the period at least of 28 working days. Card dimensions are the same as a credit card size.

Fig.5. Digital driver's card *(Source: Polish Security Printing Works)*
Rys.5. Cyfrowa karta kierowcy *(Źródło: Polska Wytwórnia Papierów Wartościowych S.A.)*

Additionally exist other types of card (company card, control card and service card), which are used for special activities. Digital tachograph communicates with user by the use of pictograms, depending on the kind of insert card. Unit also allows printing six types of basic printout version on attitude of data aggregated in unit memory or on a smart card.

Actual applied analogue units allow reading data after drive (off-line read) in opposite to gradually bringing into use digital devices. They create possibility to control driving parameters in real time. However generality and accessibility of analogue paper disc prove useful to analyse graph chart. Knowledge of driver's behaviour especially before incident state allows to create intelligent transport system, which controls online driver's reactions. It will permit to prevent dangerous roads events and optimise the style of driving.

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* State on the day 07.12. 2007

4. ANALYSIS

The analysis of driver's road behaviour is possible when using software application, processing data registered by tachograph. Data recorded as analogue graph are process into digital form. Image representation of tachograph disc goes through particular stages of reading preparation and becomes a solid basis of driving characteristics analysis and interpretation. In order to complete these operations speed, road and state of driver graphs are analysed. Application creates also the possibility to designate so-called uneconomic driving periods.

The analysis system consists of several basic operation segments. Particular operations must be executed in the proper order, in accordance with the block scheme shown below:
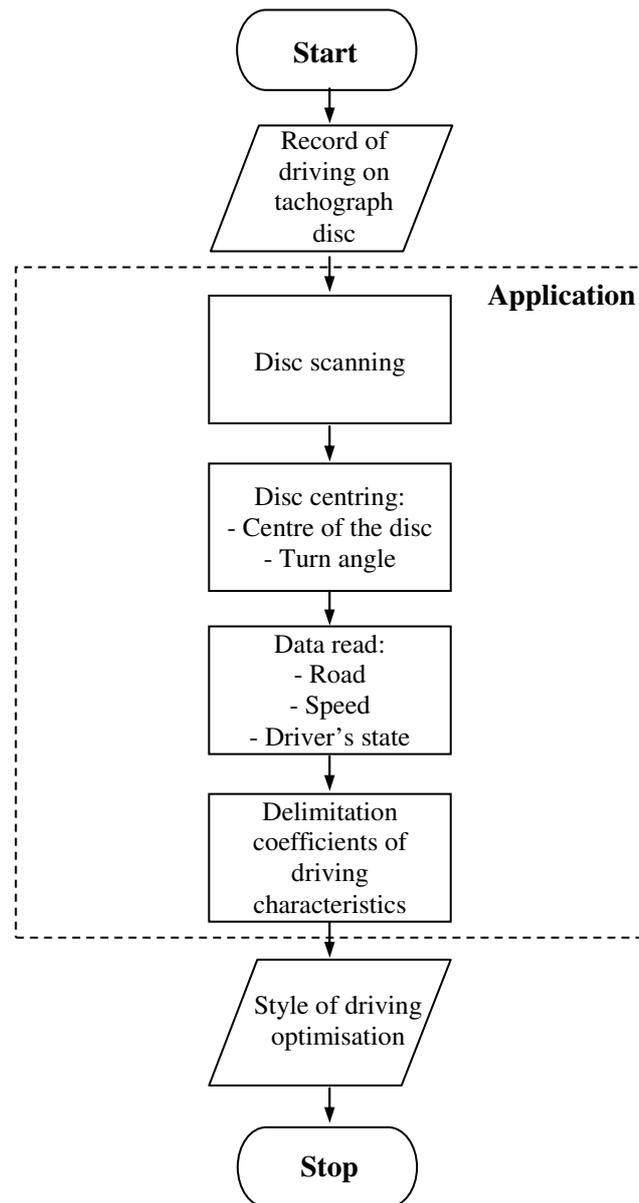
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                    │  Start   │
                    ╰────┬─────╯
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                ╱─────────────────╲
                │  Record of       │
                │  driving on      │
                │  tachograph      │
                │  disc            │
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    │             │                        │
    │   ┌─────────────────────┐            │
    │   │                     │            │
    │   │   Disc scanning     │            │
    │   │                     │            │
    │   └──────────┬──────────┘            │
    │              │                       │
    │   ┌──────────┴──────────┐            │
    │   │  Disc centring:     │            │
    │   │ - Centre of the disc│            │
    │   │   - Turn angle      │            │
    │   └──────────┬──────────┘            │
    │              │                       │
    │   ┌──────────┴──────────┐            │
    │   │   Data read:        │            │
    │   │   - Road            │            │
    │   │   - Speed           │            │
    │   │   - Driver's state  │            │
    │   └──────────┬──────────┘            │
    │              │                       │
    │   ┌──────────┴──────────┐            │
    │   │  Delimitation       │            │
    │   │  coefficients of    │            │
    │   │  driving            │            │
    │   │  characteristics    │            │
    │   └──────────┬──────────┘            │
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          │ Style of driving │
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Fig.6. Block scheme of analyse system
Rys.6. Schemat blokowy systemu analizy

Disc scanning – operation of processing analogue disc into digital image. Due to recording parameters scanning resolution in the range from 1000 dpi to 1200 dpi was applied. Graphic file should be saved in bmp format to minimize distortion of information, which essentially influence on data credibility.

Disc centring – operation of finding centre and turn angle of the disc.
- Centre of the disc – locates inside of so called "tear", which serves to place disc in tachograph unit. This parameter is indispensable, it serves as reference point in delimitation of speed, road or driver's states value. Credibility of read data depends on marking precision.
- Turn angle – specifies position of the disc and graph points on the time axis.

Data read – operation of reading analogue graph data and transforming into a digital form.
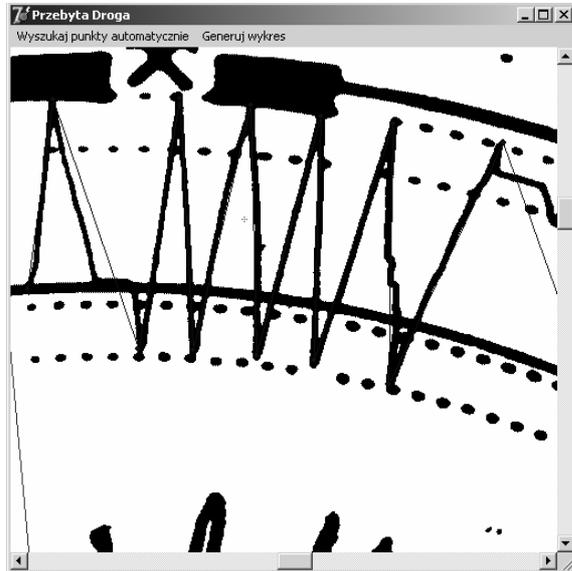
Fig. 7. Drive road graph reading
Rys. 7. Odczyt wykresu drogi

Drive road – data are read from the road graph, which tachograph unit records automatically. Application finds contra flexure points, situated on the common circle. The distance between succeeding points (upper and bottom) carries out 5 kilometres. Knowledge of coordinates particular points and coordinates of disc centre allows to reconstruct drive road record. In order to link segments of the graph used the linear approximation.

Fig. 8. Speed graph reading
Rys. 8. Odczyt wykresu prędkości

Speed – similarly as in analysing road graph, application finds contra flexure points. Every point is described with the help of diametrical coordinates. Distance of the point from disc centre defines value of temporary speed, turn angle marks position of the point on the time axis.
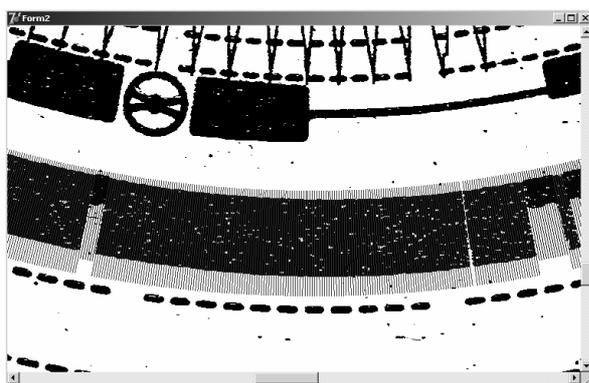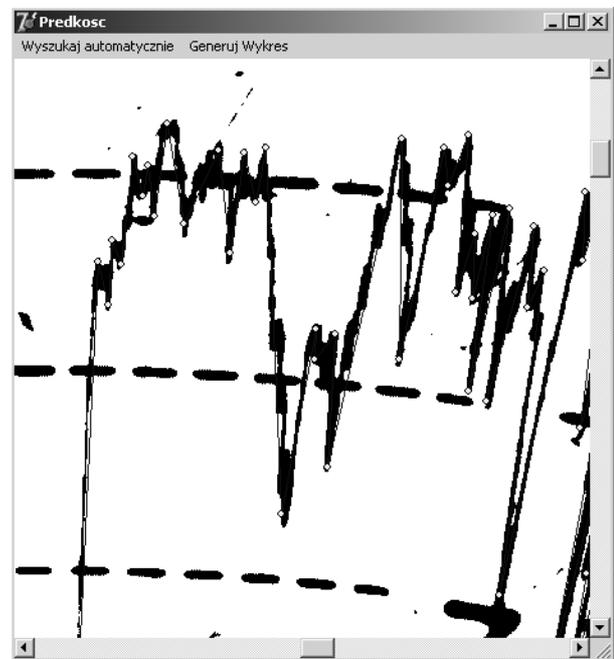

Fig. 9. Driver's states graph reading
Rys. 9. Odczyt wykresu stanów kierowcy

Drivers state – datas are marked on the basis of width line analyse. This analysis allows to define time period of particular driver states.

Delimitation coefficients of driving characteristics – operation of defining basic drive parameters such as beginning and ending time, average speed, maximum speed, average positive and negative accelerations. Additionally driving characteristic is estimating on attitude of aggregated data. Important analysis element is the designation of the speed variability graph in X,Y coordinates. The graph permits for exact analysis of driving characteristics in individual temporary moments, creating the possibility of aggressiveness and driving style qualification.

Style of driving assessment is based on average value of positive and negative acceleration. The example of driving characteristics estimate criterion is shown below.

Style of driving estimate criterion   Tab.1

Style of driving	Average positive acceleration [m/s²]	Average negative acceleration [m/s²]
Aggressive	a > 0,2	-a > 0,3
Reasonable	0,2 ≥ a ≥ 0,10	0,3 ≥ -a ≥ 0,15
Economic	a < 0,10	-a < 0,15

Several tachograph discs were analysed using presented application. Tables describing driving parameters from two real analogue tachograph discs are shown below.

Disc 1

Driving parameters record on disc no.1   Tab.2

Parameter	Graph 1	Graph 2	All
Beginning time	10:03	17:22	-
Ending time	15:24	21:55	-
Time of driving [min]	321	273	594
Distance [km]	315	280	595
Average speed [km/h]	65,09	62,27	63,68
Max speed [km/h]	94,82	94,56	94,82
Average positive accel. [m/s²]	0,092	0,118	0,105
Average negative accel. [m/s²]	-0,261	-0,146	-0,203
Style of driving estimate – accel.	Econom.	Reason.	Reason.
Style of driving estimate– braking	Reason.	Econom.	Reason..

Style of driving is described with relatively economic accelerations and reasonable way of braking too.

Disc 2

Driving parameters record on disc no. 2   Tab.3

Parameter	Graph 1	Graph 2	Graph 3	All
Beginning time	01:00	07:20	16:50	-
Ending time	05:30	13:07	21:49	-
Time of driving [min]	270	347	299	916
Distance [km]	275	315	250	840
Average speed [km/h]	62,72	60,12	58,34	60,39
Max speed [km/h]	87,72	93,65	94,94	94,94
Average positive accel. [m/s²]	0,132	0,128	0,142	0,134
Average negative accel. [m/s²]	-0,191	-0,241	**-0,399**	-0,277
Style of driving estimate – accel.	Reason.	Reason	Reason.	Reason.
Style of driving estimate– braking	Reason.	Reason.	**Agresiv.**	Reason.

Negative and positive acceleration value allows to conclude that characteristic of driving is comparatively reasonable. Significant values of decelerations occur in the third period (Graph 3). This could be the result of driver tiredness after driving for about 10 hours.

5. OPTIMISATION

Proper analysis of tachogram gives many valuable information about driving characteristic, which allows to optimise style of driving process. Optimisation process allows to:
- reduce aggressive driver's behaviour,
- minimize fuel usage,
- minimize car component wear,
- decrease negative influence on environment,
- improve road traffic safety.

According to European ECODRIVING project, training in the field of proper driving technique allows to save fuel in the order of 5-10%, without extending driving time. To assume that heavy goods vehicle yearly cover a distance of 50 thousand kilometres and use fuel in order of 20 litres per 100 kilometres, it is saving at least of 750 litres per year. In case of company having several vehicles this gives measurable financial advantage. Training within the confines of ECODRIVE project, in Germany haulage company allowed also to reduce number of road accidence in the order of 40%.

6. CONCLUSIONS

Presented In this paper implement software allows analysing lorry vehicle driving recordings in detailed. System is a supporting toll in case of describing driver's psychophysical state as well as determination of driving efficiency coefficients from economic and ecologic point of view. Analysis of vehicle tachograph disc, which participated in accidents helps to find relationship between driving characteristics and occurrence of before incidents states.

The next part of the project will be replacing data from analogue tachograph disk with information recorded on digital driver's card. Driving parameter will be read and analyse in real time. It allows to create early warning and protective system, which could be a positive influence on road safety level.

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