THE RESEARCH ON DRIVERS' BEHAVIOUR ON A CAR TRACK IN A SIMULATED ACCIDENT SITUATION

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Abstract

The following work presents research of driver behaviour in pre-accident situations conducted on Kielce Car Track within a research project N509016 31/1251. The aim of the following research work is the completion and extension of the knowledge concerning reaction times and an update to an existing data base. At the same time, driver behaviours in a particular pre-accident situation are analysed. The tests are conducted with a relatively big group of drivers, of different age and different driving experience. Reaction times are determined for three event scenarios, as it was previously mentioned, the type of scenario can significantly influence on obtained values of these times. The research conducted in a pre-arranged risk situation, where an obstacle in a form of a car mock-up suddenly forces its way into a road area with a simultaneous limitation of "room" for a manoeuvre by a lorry mock-up moving on the opposite lane and opposite direction. This work presents the pattern and scenario course of a pre-accident situation selected for tests. Measuring equipment and movable mock-ups used for research were characterised. There were presented selected, preliminary results of three trials characterised by different values of risk time (different level of accident risk). The following article presents the patterns of the first pre-accident situation under research, the research method and example research results obtained on Kielce Track.

Keywords: *pre accident situations, driver behaviour, driver reaction times*

1. Introduction

In the analysis and accident reconstruction, the task of an expert is usually to try to answer a question: what was the course of an accident and "who is to blame for it"? The answers to such a question cannot be given easily. There are usually so many ambiguities and doubts that it is necessary to carry out a detailed analysis of the ensuing event. Modern road accident analysis is frequently supported with specialist computer programs (e.g. V-Sim, PC-Crash, etc.), which enable an event reconstruction and considerably speed up to draw conclusions in opinions for the judiciary bodies.

Unfortunately, this so called "a perfect solution" has its disadvantages. It cannot be used without the knowledge of a big number of parameters connected with a road, a vehicle and driver. Some of them may be known for a person who analysis the situation from the police report, whereas others have to be assumed or taken from available literature [7], [10], [13], or from expert's own experience. In this scope, the problem of a subjective choice of particular parameters may arise. The computer program in the hands of an inexperienced person may happen to be a tool which prevents from conducting correct analysis. Additionally, a lot of existing programs has a very good developed graphic interface (with the possibility to conduct complex animations placed on a real accident spot), which may further lead to the situation where even absurd analysis may be shown to the court in a very suggestive manner.

One of such parameters taken into consideration by experts in the above-mentioned programs is driver reaction time. Generally, it is adopted on the basis of extensive literature. In most available materials, reaction time values are estimated but this lacks information concerning the drivers for whom they were given. The way of measurement, kind of scenario, conditions in which tests were carried out have not been mentioned. In connection to that, “betting on” such reaction time values is risky as the article authors stated before, driver reaction time depends not only on trial parameters [2], [3], [6], [10] but also on a scenario itself [11], [12].

The aim of a research work N509 016 31/1251 prepared by teams from Technical Universities in Kielce, Warsaw and Cracow, is the completion and extension of the knowledge concerning reaction times and an update to the existing data base. At the same time, various aspects of driver behaviours are analysed in particular pre-accident situations. The tests are conducted with a relatively big group of drivers, of different age and different driving experience. Reaction times are determined for three event scenarios, as it was previously mentioned, the type of scenario can significantly influence on obtained values of these times.

In a comparable manner to previous tests [1], [4], [5], [9], risk time has been applied, defined as the time from the moment of occurrence (noticing an obstacle by a driver) to a possible collision with it. Risk time is estimated as a quotient of the distance from an obstacle to a car speed. In quoted works, the authors demonstrated that risk time is a very good parameter to characterise a pre-accident situation. Many parameters which characterise this situation and driver behaviour are a risk time function. In current research also a lot of parameters will be determined as risk time functions for other quantities, for which time routes will be determined, risk time exists as a parameter that characterises a particular trial.

The following article presents the patterns of the first pre-accident situation under research, the research method and example research results obtained on Kielce track.

2. The scenario of an accident situation and research characteristics

For research realization was selected a pre-accident situation which was a sudden appearance of a testing vehicle, marked in Fig. 1 as “vehicle” - an obstacle in the form of another vehicle, marked in Fig .1 as “obstacle 1” driving from the side. Similar tests, for another scenario, have been realized by the authors before [1], [3], [6].

An obstacle appeared on the road suddenly form the right side. Such situations happen quite often on housing estates, surrounded by high fences or hedges or at other crossroads, where an avenue of trees or a high vehicle parked there, cut out the vision. To limit the room for manoeuvre performance, a testing vehicle model (mock- up) Ford Transit “obstacle 2” was moving from the opposite direction. The road area was surrounded by both sides with cardboard “pavements”.

The mock- up (similarly to other mock- ups) was realized as an original design, realized within N509 016 31/1251 research work. Mock - up movements were realized in runners (behind a shutter). The propulsion used was of ejector type. The speed of a mock-up was selected according to an accepted scenario. The mock – up is remote-controlled (radio control), by a signal from a photocell fixed at the testing vehicle, at the moment of driving next to a point distant from an obstacle by a characteristic value of a particular trial.

The “obstacle 1” mock- up is built from polyurethane foam covered with fabric – Fig. 2. At the front of the mock- up has been stuck a printed in real sizes a view of a car (Opel Zafira) used in identical tests in a simulator. The obstacle mock- up was adjustable to limit collision with the testing vehicle (to provide safety during tests).

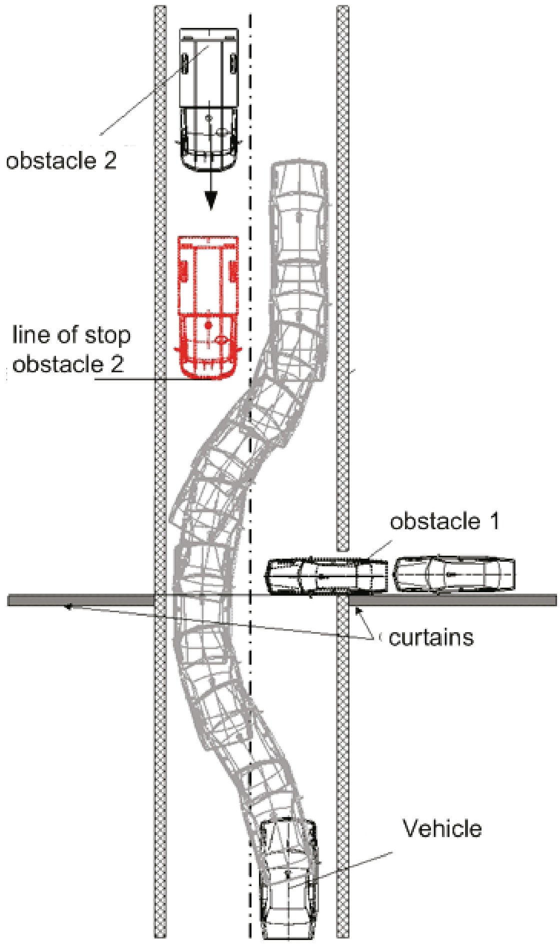

Fig. 1. A scenario pattern realized on Kielce Track

Fig. 2. An obstacle 1 mock-up made of polyurethane foam

To provide the possibility to compare obtained test results in both testing environments (on the track and in the simulator), a Polonez car was used (its parameters were loaded to the simulator software).

During experimental tests on the track the following values were measured and registered:

- component: longitudinal and lateral of a selected car body part, non-contact method with the use of two-parameter head of the Correvit system,
- component: longitudinal and lateral of an acceleration point vector, located near mass centre of the car (with the use of multi-parameter and integrated Crossbow measuring block, with laser gyroscopes and piezoelectric converters of acceleration),
- yaw velocity and roll velocity of car, with the use of the above-mentioned equipment,
- angle of steering wheel with the use of a precise resistor converter of the Kübler system,
- angle of waste-gate opening with the use of resistor converter,
- service brake displacement with the same type of converter.

Additionally, a signal from STOP lights was registered.

All measured values were appropriately processed and registered in a specialised analogue and digital converter (AD12), which works and is steered by a Laptop computer. The applied measuring system allows free programming of the converter and automatic visualization of measured signals directly after every trial, which enables quick verification before saving on a computer disc. Fig. 3 shows a testing car and some testing equipment.

The beginning of the trial was realized automatically by a photocell in a desired (and regulated) distance from the obstacle. A radio system integrated with a barrier light triggered obstacle movement automatically.

Fig. 3. The view of a testing vehicle and the part of equipment: Correvit double parameter head system (the measurement of longitudinal and lateral component of a velocity vector of a selected car point), a steering wheel angle converter with a line transmission, eight-parameter Crossbow measuring block (used for measuring yaw velocity, roll velocity, the components of longitudinal and lateral acceleration vector of a point near the mass centre). AD 12 converter with plugged cables of measured signals, controlled by a laptop computer. The car has been equipped with a special Safari type bumper protecting the car front during a collision with the obstacle

To limit an access road for a driver on the opposite lane, a Ford Transit mock- up was moving from the opposite direction – Fig. 4. The mock- up is electrically-powered and moves on rails. The start of the mock-up was realized manually and stops automatically. The construction of the mock-up provided safety in case of a collision with a testing car.

Fig. 4. The car mock-up approaching from the opposite direction –"obstacle 2"

The tests were conducted for the same group of 100 drivers, which underwent tests according to an identical scenario in the simulator. Among tested drivers, the majority, i.e. 70, were young people under 25 years of age. In this age group, two testing groups were distinguished: with major and minor driving experience. Each group consisted of 35 people. Additionally, three groups of older drivers were selected: 10 people between 26 and 35 years of age, 10 between 36-45 years of age and 10 people above 46 years of age.

Drivers' tasks were to try to avoid a collision with the obstacle appearing on the road but the way of reaction was not imposed on the drivers. Depending on a subjective and individual assessment of the situation, each driver could only brake, only avoid the obstacle or react in a more complex manner, using both ways with different "intensity".

Fig. 5 presents a part of drive, where a driver tried to avoid "obstacle 1" appearing on the road.

Fig. 5. Performing the manoeuvre of avoiding during tests

The manoeuvre of avoiding was hindered by "obstacle 2" moving from the opposite direction. The driver should have aimed to avoid the collision with that obstacle, too.

Each driver performed 17 trials. As a basic parameter, which characterises a trial was risk time. The range of this parameter change was adopted on the level between 0.5s to 3.6s. Individual values of risk times were obtained as a combination of car speed and distance from the obstacle:

- the speed of a tested car: 36, 40, 45, 50, 60 km/h,
- distance from a car, at which a driver noticed an obstacle: 5, 10, 20, 30, 40 and 50m.

About 2000 trials were conducted in this way. Tests' parameters were introduced in Tab. 1. With the aim to avoid routine actions of drivers during further trials, the parameters of trials were altered randomly and they were not known to the drivers, and what is more, there were “blind drives”, when an obstacle appeared. In case of track tests, due to safety purposes, the authors resigned from tests for the lowest risk times (in relation to tests in the simulator).

Tab. 1. Values of risk times for considered tests on the track

Risk time, s	Car speed, km/h	Distance from an obstacle, m
0.5	36	5
0.6	60	10
0.72	50	10
0.8	45	10
0.9	40	10
1.0	36	10
1.2	60	20
1.44	50	20
1.8	40	20
1.8	60	30
2.0	36	20
2.16	50	30
2.4	60	40
2.7	40	30
2.88	50	40
3.0	60	50
3.6	50	50

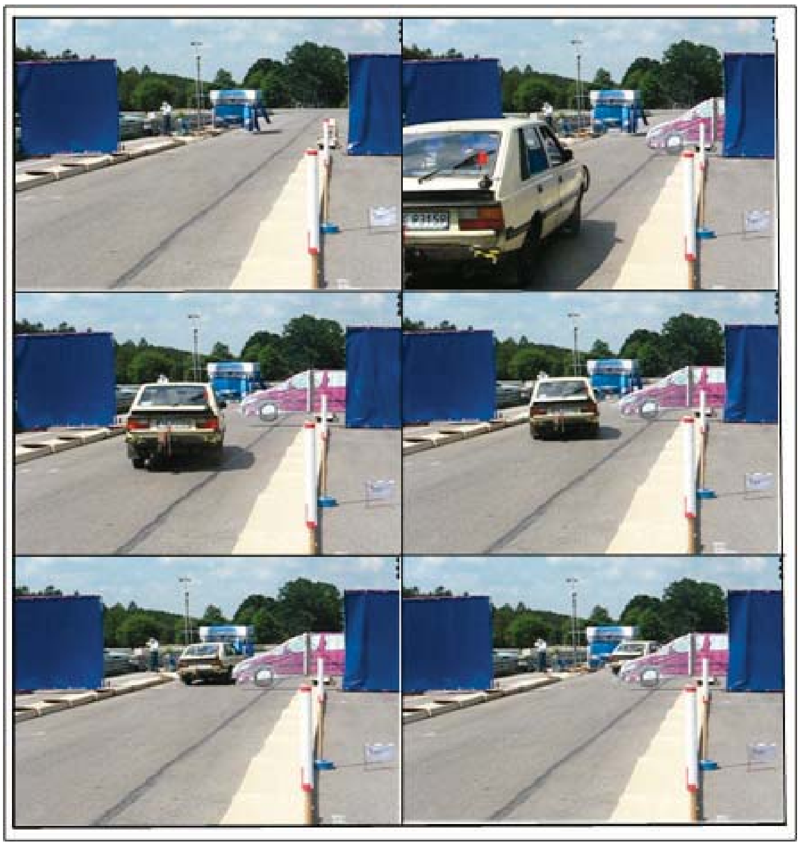

Fig. 6. Subsequent phases of testing vehicle drive in an accident situation – successful trial to avoid an obstacle

During many trials a car collided not only with a car but also with a lorry model. Film frames from particular drives have been illustrated in Fig. 6 and 7, where Fig. 6 shows a situation, in which a driver managed to avoid a collision with both of obstacles, and Fig. 7 – a situation, in which a collision with the first obstacle occurred.

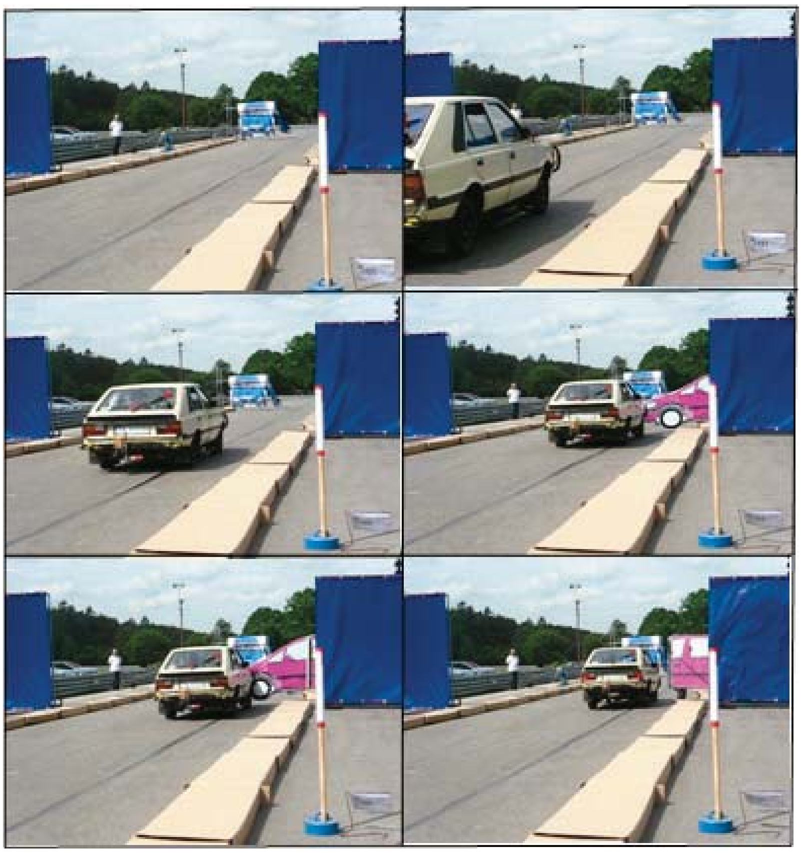

Fig. 7. Phases of testing vehicle drive during a trial, where a collision with the first obstacle happened

3. Preliminary example results of track tests

The quantities that characterise each drive (the parameters of a tested car movement and an obstacle, quantities describing driver behaviour) were registered. For the purposes of the following work, among many possible assessment criteria of driver behaviour, the work focused on:

- the way a driver reacted (turned, used a brake, etc.)
- driver reaction time (understood as the period from the moment when an obstacle becomes visible to the moment of driver reaction)

Fig. 8 - 10 present example drives for a selected driver, for three trials characterised by different values of risk time: t_{R0}: 0.6; 1.44 and 3.6 s.

Assigned reaction times for a chosen driver have been presented in Tab. 2.

Tab. 2. The example of driver reaction times obtained during tests on the track

Risk time, s	Reaction time		
	Braking with an engine, t1, s	Steering wheel turning, t2, s	Braking with a service brake, t3, s
0.6	0.8	0.95	0.93
1.44	1.11	0.72	1.26
3.6	1.48	1.27	1.93

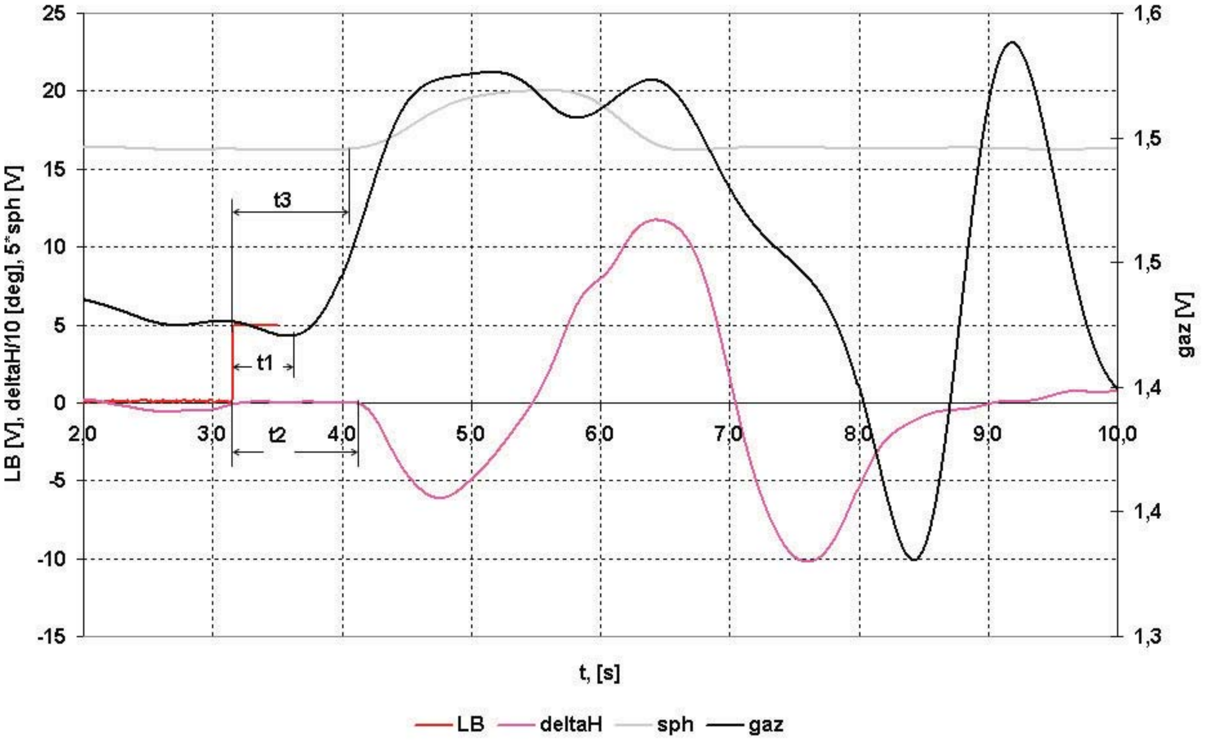

Fig. 8. The example of obtained results for the chosen driver with a trial of risk time 0.6 s (S=10m, V=60km/h). Labels: delta H, angle of steering wheel turning, the gas-angle of a waste-gate opening, LB-light barrier, sph-brake pedal route, t1-reaction time with an acceleration pedal, t2-reaction time of steering wheel turning, t3- reaction time with a brake pedal

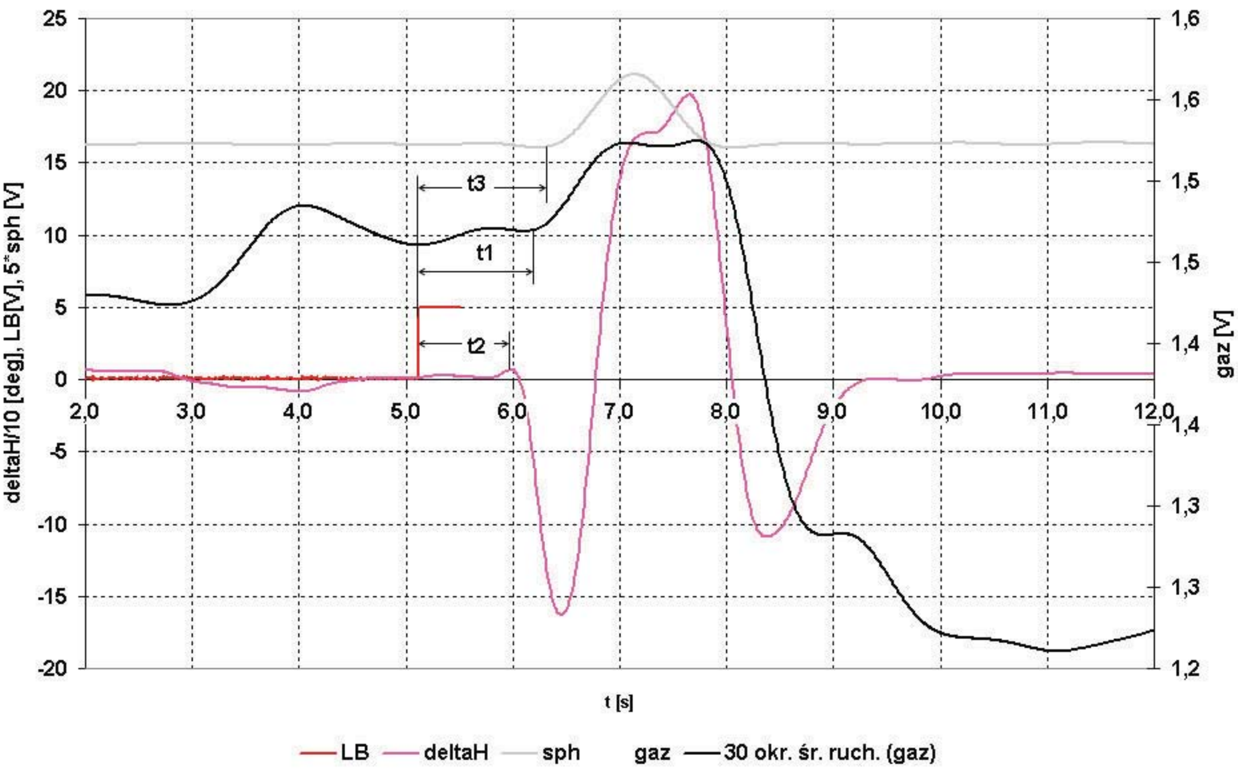

Fig. 9. The example of obtained results for the chosen driver with a trial of risk time 1.44 s (S=20m, V=50km/h). Labels as in Fig. 8

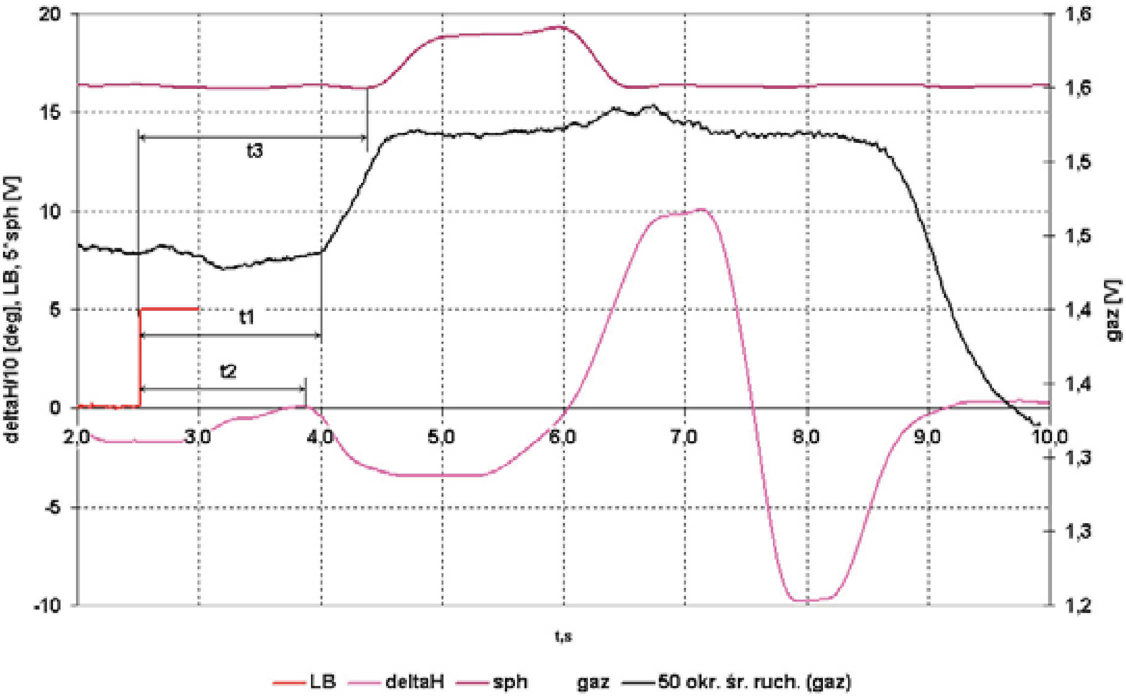

Fig. 10. The example of obtained results for the chosen driver with a trial of risk time 3.6s (S=50m, V=50km/h). Labels as in Fig. 8

Fig. 11 shows the influence of a side strike into a car on signals, angle turning wheel (deltaH), the yaw velocity (fiprim), roll velocity (the psiprim) and lateral acceleration (ay). The trial has been presented earlier in Fig. 9, where reaction time was estimated.

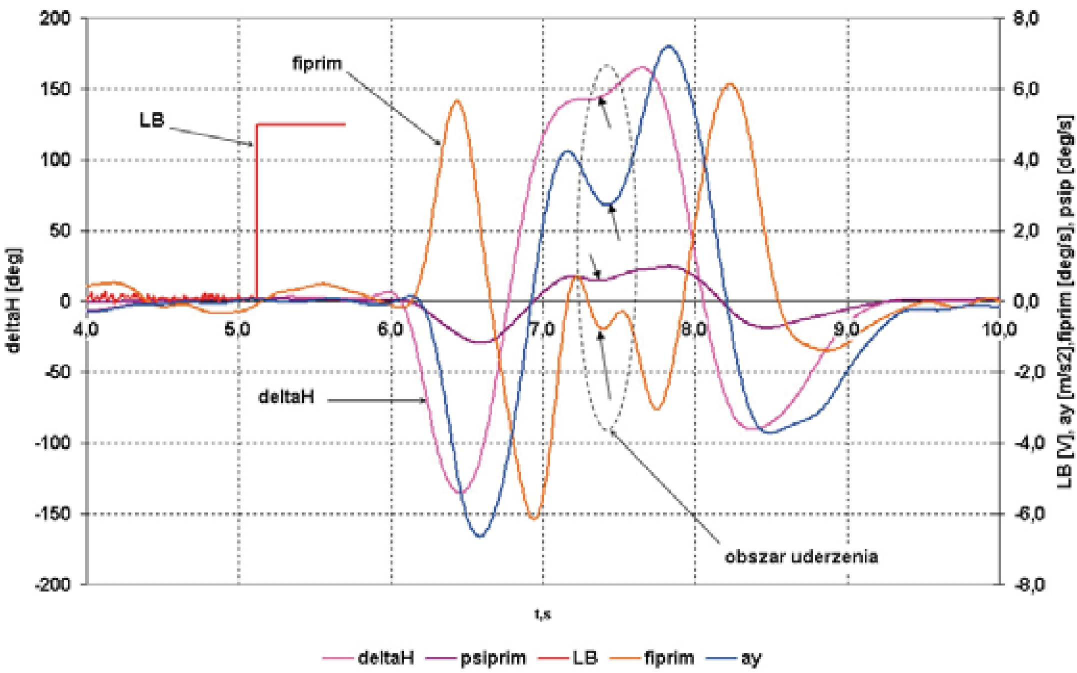

Fig. 11. The influence of obstacle strike into the side of a car on chosen movement parameters

4. Summary

Track tests are undoubtedly a vital element of the following work. Organization of tests in such a range was a large-scale technical, organizational and financial undertaking. Moreover, during tests realization numerous difficulties occurred, also due to weather conditions. A big impediment for a team dealing with experimental road tests is lack of an appropriate training ground, accessible firstly to those groups. This problem has been indicated and emphasized for many years, mainly during conferences and meeting of that group of specialists. However, until now, in macro scale, the issue has been impossible to solve.

Despite these difficulties, a big research material, which is now being processed, has been collected. Preliminary results point to legitimacy of undertaking such an important subject and the correctness of its realization.

The experimental verification on the track of the tests conducted in the simulator has been started for the remaining two pre-accident scenarios.

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