ꟼ periodica polytechnica

Transportation Engineering
36/1-2 (2008) 41–46
doi: 10.3311/pp.tr.2008-1-2.08
web: http://www.pp.bme.hu/tr

RESEARCH ARTICLE

Development of a measurement station and a procedure for measuring differences between standard and proportional stop lamps

Róbert Fekete / *György* Ábrahám

Received 2007-03-03

Abstract

The first part of this article describes a novel proportional stop lamp under development at our department. The stop lamp is capable of signalling braking intensity. The second half of the article details a measurement process and an instrument measuring the difference in the effects of standard stop lamps and the proportional stop lamp on the driver.

Keywords

supporting systems · proportional stop lamp · brake intensity · reaction time · reaction curve · measuring instrument · measurement process

Róbert Fekete
Department of Mechatronics, Optics and Mechanical Informatics, BME, H-1111 Budapest Egry J. u. 1-3, Hungary
e-mail: frt@mom.bme.hu

György Ábrahám
Department of Mechatronics, Optics and Mechanical Informatics, BME, H-1111 Budapest Egry J. u. 1-3, Hungary
e-mail: abra@mom.bme.hu

1 Introduction

There is a worldwide stream of research on developing intelligent systems capable of controlling vehicles. The light supporting the driver have a large contribution in the reduction of traffic accidents. Thus, there is a demand for widening the usage of lights in traffic beyond the results of past research and development.

Early in 2006, our department has designed a proportional stop lamp signalling braking intensity, based on the patent turned in by György Ábrahám PhD on 5th February 1998. This stop lamp is presented in Section 2.

The proportional stop lamp is justified with thorough research and human testing. Based on the justification, at the end of 2006, our department has created a measurement process providing reliable data service, and a mobile measuring instrument belonging to the service, detailed in Section third.

2 A proportional stop lamp signalling brake intensity

Normal stop lamps have been used in everyday traffic for a long time. They were first made obligatory in 1965, in Great Britain. Since then, the build-up of stop lamps is in essence unchanged. Therefore, many researchers focus on the effects of stop lamp types on the safety of car transportation.

The well-known research ideas largely contribute to make traffic safer. However, as far as we know, none of them focuses on designing a stop lamp different than the currently known constructions. Therefore, the possibility of providing supplementary information has been rejected. The design of the proportional stop lamp presented below on the other hand provides the drivers with supplementary information, which is a novel method of increasing traffic safety.

The standard types of stop lamps are activated upon pressing the brake pedal, and the information transmitted to other participants of the traffic is a binary value, either true or false. As a result, a driver following a car has lack of information on the state of movement of the car he or she follows, which can lead to faulty decisions, or even collisions.

3 Signalling the state of movement of vehicles with lights

A device made of light emitting diodes presented below, provides visual information on the state of movement of vehicles, informing other participants of traffic on movement data at a glance.

The proportional stop lamp signalling braking intensity could be placed on the bottom or on the top of the rear windshield of vehicles, perpendicular to their longitudinal axis in a way that their emitted light can only be seen from the outside. Braking intensity is proportional to the number of illuminated elements, or in other words, the length of the light strip. A short light strip signals weak braking, while a long light strip signals strong braking. Obviously, more than one braking states can be signalled between the two endpoints of the strip. The colour of the emitted light is practically red. The length of the illuminated strip increases from the midpoint of the strip to the left and the right, symmetrically with the increase of the braking force. In order to make the estimation of the braking force independent of the distance of the observer, the proportional stop lamp occupies the whole width of the rear windshield, and the units at its two endpoints are always illuminated. Therefore, the length of the illuminated segment can be correlated with the whole length of the light strip, which allows the follower to estimate braking intensity of a vehicle independent from the follower's distance.

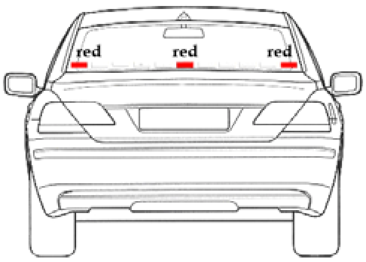

Fig. 1. Easy braking state of the proportional stop lamp

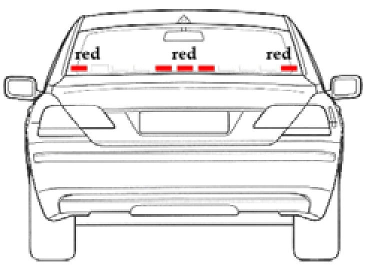

Fig. 2. Medium braking state of the proportional stop lamp

4 A process and an instrument measuring the different stop light's effect on the driver

The aim of the measurement is to acquire a representative reaction curve from the human test subjects. A reaction curve illustrates the intensity of the reaction of the subjects in time. We have measured the brake intensity of the subjects in case of

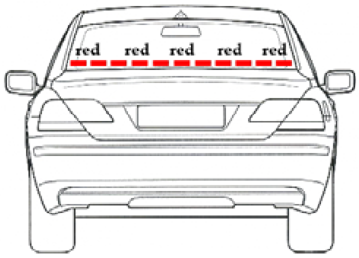

Fig. 3. Full braking state of the proportional stop lamp

different traffic situations. Based on the gathered data, the reaction curve can be determined. The other aim is to significantly demonstrate the difference of driver responses to traffic situations where the driver follows vehicles equipped with regular stop lamp or vehicles equipped with proportional stop lamps.

When designing the measurement process, it was very important to import life like circumstances into the simulation environment as realistically as possible. During the measurement, the subjects are given by simulated videos, and they can react at the traffic situations using the steering-wheel and pedal devices of a simulator. Subjects have to be placed at a given distance from the screen such that the difference between the real viewing angle and the theoretical viewing angle determined by the distance of the vehicles drawn on the screen should be as low as possible.

5 Devices

A measuring program written in data gathering software and the spreadsheet software facilitating data processing and evaluation are important devices of the measurement process. The videos have been made using three-dimensional animation software.

Another device used in the measurement is a force feedback simulation steering wheel and the pedals belonging to it. The response curve was mainly determined using the signals of the brake pedal signals of the steering wheel and the acceleration pedals have also been recorded. The measurement range of the brake pedal is 38 mm. This range is split into 32 767 segments, allowing high-resolution observations. One unit difference corresponds to 0.1 mm shift in the brake pedal location. Signals of the steering wheel and the pedals are transmitted to the computer registering the measurement through USB cable.

The simulated videos have been projected to a screen 1955 mm in diameter using an SVGA 800 x 600 projector in a dark room.

6 Measurement task

The task of the subjects is to realistically and proportionally react to the different projected traffic situations. Every situation includes a vehicle running at constant speed in front of the car driven by the subject during a time interval unknown to the subject. After this time interval, the car brakes with an unknown braking force. The subject needs to consider the observed braking intensity, the distance of the braking car and his car and the degree of the emergency situation, and then react to the situation by pressing the brakes using a force proportional to the braking intensity the subject determines based on the information he or she has gathered. The length and intensity of applying the brakes are both recorded.

7 The measurement process

During the measurement, the subject is trained, and then 24 different simulation videos are shown. The steps of the measurement process are the followings:

Placing the subject in front of the screen: In order to acquire a viewing angle which is close enough to the theoretical viewing angle, the distance of the subject and the screen is 3 meters. In order to correctly adjust the altitude, the head of the subject should be at the same height level as the line of projection of the videos. The steering wheel and the pedals have to be adjusted as well according to the preferences of the subject.

Explaining the measurement experiment to the subject: in order to make the subject clearly understand the task, some sample videos are presented to the subject that is similar to the ones he will face.

Playing the 24 simulational videos continuously to the subject: While the videos are displayed, the subjects continually gather data. The responses to the traffic situations based on the simulation videos are filtered from the whole data set at later time.

8 Measurement program

The program applied in the measuring instrument is implemented using data gathering software. The control panel of the program consists of a data file field, a field signalling the state of the acceleration and the brake pedals, and a corresponding chart. During the measurement process, the program stores pedal states belonging to the measured time instants in a given file. The pedal states are read from the USB joystick port.

The Figs. 4-5 show the block diagram and the control panel of the program.

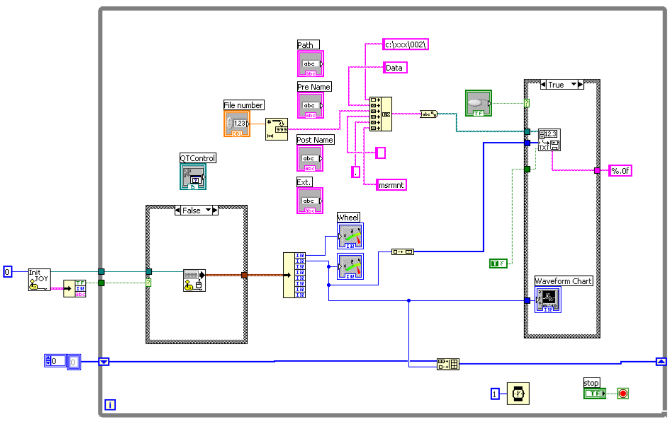

Fig. 4. Block diagram

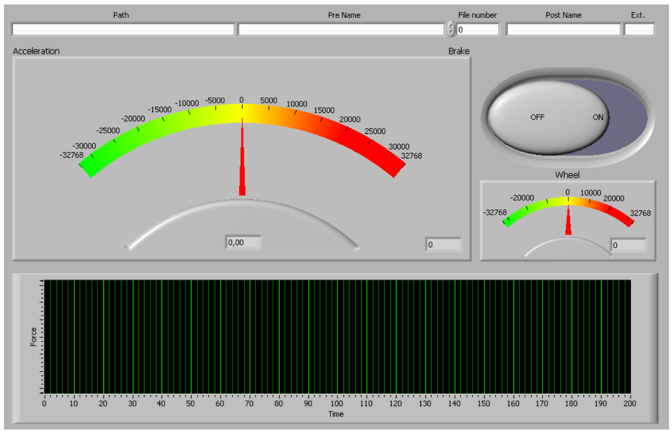

Fig. 5. Interface

9 Simulation videos

The most important aspect of selecting the proper test videos was that they should simulate realistic traffic situations, and they have to enable the comparison of the standard and the proportional stop lamps. Therefore, the videos have been made in a way that the subjects can take part in each traffic situation twice: once they drive behind vehicles equipped with standard stop lamps, and once the vehicles are equipped with proportional stop lamps. The simulated situations are played in an unknown random order.

Simple scenarios are based on traffic situations when the observer follows a car travelling on a straight road. The scenarios can differ in three ways: the distance between the vehicles or the braking intensity can differ, and some videos contain proportional stop lamps, while others contain standard ones.

There are twenty-four simulation videos for examining these simple situations.

Although simple situations are eligible for presenting the fact that different stop lamps produce different reactions in the subject, most of the traffic situations are still not covered with these cases. Therefore, in order to prove the advantage of proportional stop lamps, it would be needed to examine many other situations.

The concept of creating the videos is based on the assumption that the driver of the follower vehicle copies the motion of the car he or she follows, with a time delay. When copying the motion of the car in front, the follower car inherits the acceleration state of the front car, what implies that the velocity and relative location states equal as well.

This concept has been chosen from several different alternatives. Other alternatives were rejected due to the fact that in some form, they all worked under the assumption that the expected reaction time of the subject is known in advance. However, this assumption would be a possible source to influence the response, what would make the measurement process less genuine.

The design of the scenarios belonging to the simple situations is simplified using a composite table which immediately recalculates the states of the vehicles and displays them, based on the change in the input parameters such as acceleration data, reaction time, initial distance etc. using kinematics and equations. This table makes it easier to judge how realistic a scenario is. Input parameters are the initial velocities and locations, the highest possible values of the acceleration and deceleration, length of the time interval when the vehicle is at constant velocity, the reaction time, and the value of the lowest possible distance between the two cars. Based on these data, the program calculates the length of accelerating and decelerating motion segments, the velocity, location and distance at each instant. The calculation is based on the fact that the acceleration is constant in the accelerating and decelerating motion segments and the increase in the value of the acceleration is instant. Segments where the cars travel at constant velocity precede accelerating and decelerating segments, where the length of the constant motion can also be set. The initial and minimal distances of the two cars are the boundary conditions. Velocities and locations can be calculated from these data using numeric integration.

The videos used in the simulation are made using a three dimensional modelling software, which enables placing the modelled vehicles, the observer camera and many other spectacular objects in the videos. These elements are houses and other objects seen in the background, and other vehicles travelling on the road. Similarly to real traffic situations, these objects make the scene more complex, in order to split the attention of the subject.

Fig. 6. A frame from an animation video

After location and acceleration data have been formed, they can be transmitted from the spreadsheet software to the 3D software. Based on these data, the location of the vehicles at any time data, the lighting state and intensity of the proportional and standard stop lamps can be set. Due to the dire transmission, the physics of the motion is completely realistic. After the models, their motion and the location have been set, the animations are enhanced by providing effects making the animations more realistic, shadows and lights, which can be turned on or off according to the situations and preferences. These high-quality videos have been made using several computers, so that their quality is high enough to be usable despite the high resolution of the screen.

10 Methodology of acquiring the results

Data are taken from the available data files into the spreadsheet software. Data are then processed, and charts are made for illustrating the differences.

During the test phase of the measurement, we focused on developing the measurement process, i.e. we tried it out and improved it. Sufficient numbers of measurements have been made, however, since there are no other measurement results than the test measurements, obviously we cannot refer to a representative pattern. However, one of the most important advantages of the LED-stripped system is that it provides calmer driving circumstances. This advantage can be perfectly seen from the small-sized pattern as well. For more details, examine the figures below. Although the statistical pattern is not representative, this result cannot be suppressed.

The property that the braking curve is more balanced when using proportional stop lamps can be concluded from the charts. This suggests that the drivers observed the braking intensity of the follower vehicle and they brake based on this information, unlike situations where standard stop lamps were used, where the driver could only see that the car in front has braked with an unknown intensity. Therefore, whenever they observe that the car in front brakes, they immediately touch the brakes, not even considering the brake force, which can only be considered afterwards. In many cases, the drivers inferred the necessary braking intensity based on the change in the size of the car in front, and then they acquired the intended effect by repetitive changes in the applied force. However, the necessary brake force was almost immediately known in case of situations when proportional stop lamps were used.

11 Evaluation

Our aim was to design a measurement process measuring human reaction curves. The goal of the measurement is to examine the brake intensity of the drivers at different traffic circumstances. The results of the measurement process are reaction curves – brake intensity as a function of time. The standardized behaviour of drivers under circumstances when the vehicles are equipped with different stop lamps is derived after sufficient number of measurements. Therefore we have created a measurement process and a measuring instrument, and we have also tested them after they have been built. The process needs more fine-tunings, which is the key to make future advancement with this technique. During research, we have become it more and more certain that the proportional stop lamp displaying braking intensity would have a big advantage on the roads, and it is certain that it would positively influence the safety of traffic. However, in order to introduce this novelty in everyday traffic, it has to be tested, and we believe that our past and present research has largely contributed to this process.

According to the related Hungarian rules and regulations for the light emitting signals of cars being put into or keeping in traffic, KöHÉM enactment no. 6/1990 (12th April), in accordance with international rules and regulations, does not prohibit the use of a light emitting device being able to display the intensity of braking illustrated in this article on the roads. Based on this fact and the results of our research so far, it can be stated that the use of this device on the roads would bring several advantages provided that it is adjusted with present standards. We can state in advance for future research results that this device would probably decrease the number of accidents through increasing available information and decreasing mental stress on the roads.

12 Diagrams

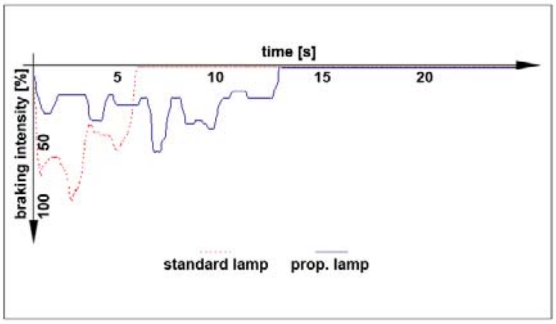

Fig. 7. Sample graph: small distance, engine brake situation

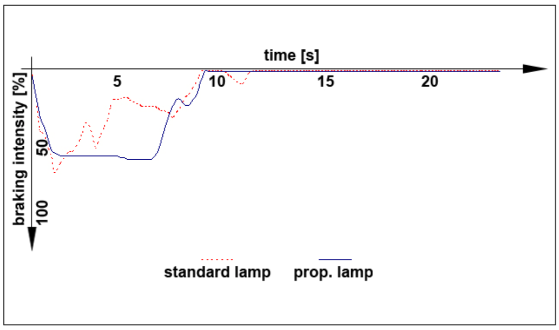

Fig. 8. Sample graph: small distance, easy brake situation

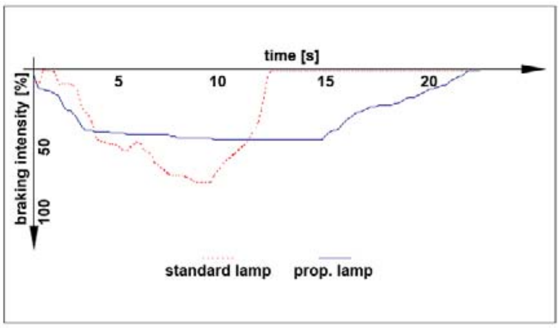

Fig. 9. Sample graph: small distance, medium brake situation

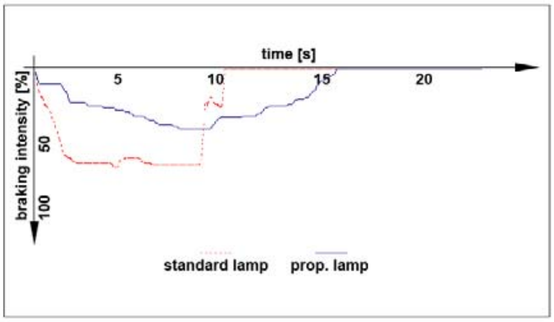

Fig. 10. Sample graph: small distance, full brake situation

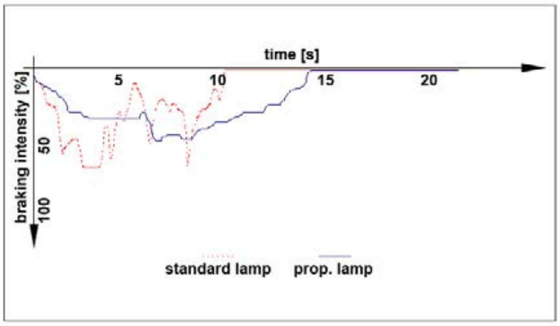

Fig. 11. Sample graph: medium distance, engine brake situation

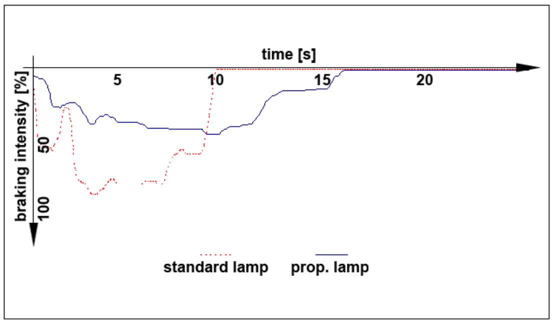

Fig. 12. Sample graph: medium distance, easy brake situation

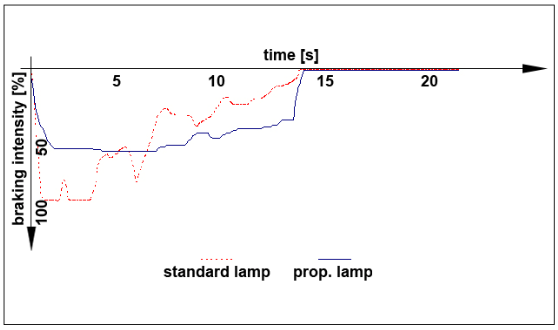

Fig. 13. Sample graph: medium distance, medium brake situation

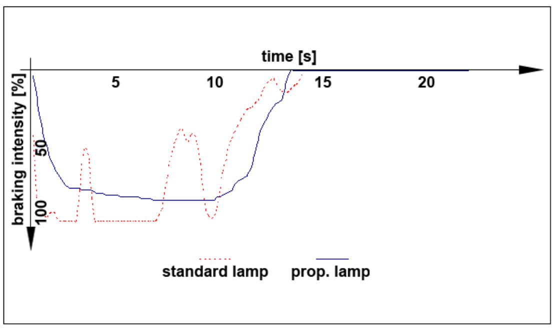

Fig. 14. Sample graph: medium distance, full brake situation

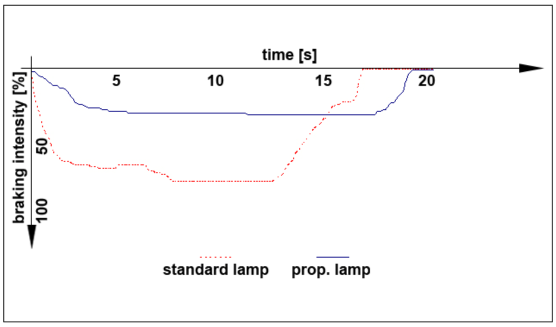

Fig. 15. Sample graph: big distance, engine brake situation

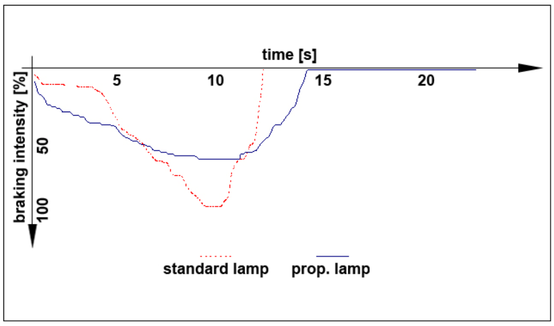

Fig. 16. Sample graph: big distance, easy brake situation

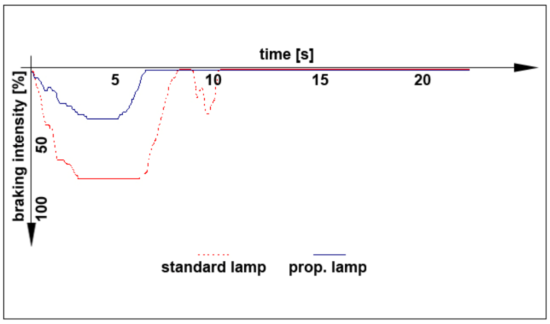

Fig. 17. Sample graph: big distance, medium brake situation

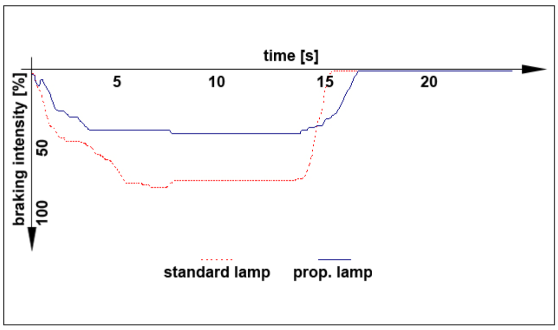

Fig. 18. Sample graph: big distance, full brake situation

References

1 **Chapman G**, *A brief history of road safety*, 2006, available at http://www.chapmancentral.co.uk/web/public.nsf/documents/history?opendocument.

2 **Voedovsky J**, *Inferences from Visual Perception and Reaction Time to Requisites for a Collision-preventing Cyberlite Stop Lamp*, 2006, available at http://www.pubmedcentral.nih.gov/picrender.fcgi?artid=335563{\&}blobtype=pdf.

3 **Farmer CM**, *Effectiveness estimates for center high mounted stop lamps: a six-year study*, Accident Analysis and Prevention **28**, no. 2, 201-208.

4 **Kahane ChJ, Hertz E**, *The Long-Term Effectiveness of Center High Mounted Stop Lamps in Passenger Cars and Light Trucks.*, 2006, available at http://www.nhtsa.dot.gov/cars/rules/regrev/evaluate/808696.html..

5 **Kletensky D, Kubena V, Neumann R**, *Rear Lamp Reaction Time Study - Comparison of Incandescent Bulbs and LEDs.*, 2006, available at http://www.visteon.com/utils/whitepapers/2002{_}01{_}0379.pdf..

6 *Criteria for the automatic activation of stop lamps.*, 2006, available at http://www.dft.gov.uk/stellent/groups/dft{_}roads/documents/pdf/dft{_}roads{_}pdf{_}611792.pdf.. Department for Transport.

7 **Ábrahám Gy**, *Járművek mozgásállapotának fényjelek útján történő külső kijelzése*, 1998. Oltalmi beadvány,.

8 **Palkovics L**, *Intelligent vehicle systems*, Budapest University of Technology and Economics, 2005, available at www.mindentudas.hu.

9 **Petrók J**, *Media information*, University of Technology and Economics, Budapest, 2005, available at www.knorr-bremse.hu.

10 **Rainer K**, *Media information*, 2005, available at www.bosch.hu.

11 **Bokor J**, *Intelligent vehicle-, road system*, Budapest University of Technology and Economics, 2004, available at www.matud.iif.hu.

12 **Palkovics L**, *Vehicle control and stabilizing*, Budapest University of Technology and Economics, 2005, available at www.knorr-bremse.hu.

13 **Lindenbach Á**, *Intelligent traffic systems in vehicular transport*, Budapest, 2004.

14 **Jankó D**, *Vehicular transport safety*, Novadat (1996).

15 **Kőfalvi Gy**, *Traffic fundamentals*, 2005.

16 **Kőfalusi P**, *From the ABS to the ESP, electronic dynamical control systems*, 2005.

17 ______, *Antilock brake systems of automobiles*, Jaurinum (1997).

18 **Egerszegi K**, *Intelligent systems, active applications*, Budapest University of Technology and Economics, 2001.

19 **Ábrahám Gy, Fekete R**, *Járművek fényjelekkel történő kooperatív irányítása*, Budapest University of Technology and Economics, 2006. (EJJT).