Transmitted by the expert from GTB

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agenda item 5(d))

Proposal for Amendments to Regulations 48 and 123

The text reproduced below was prepared by the expert from the Working Party "Brussels 1952" (GTB) to provide supporting information in relation to the proposals to introduce, into regulation No. 48 and No.123, provisions for the automatic activation and deactivation of the main beam. This supporting information applies to documents: ECE/TRANS/WP29/GRE/2010/40, ECE/TRANS/WP29/GRE/2010/41 and ECE/TRANS/WP29/GRE/2010/42.

Adaptive Main Beam

Proposals for Amendments to Regulations 48 and 123

This document provides the supporting rationale for the following documents:

ECE/TRANS/WP29/GRE/2010/40

(Regulation No. 48 - Adaptive Main Beam)

ECE/TRANS/WP29/GRE/2010/41

(Regulation No. 48 - Automatic Activation / Deactivation of Main Beam)

ECE/TRANS/WP29/GRE/2010/42

(Regulation No. 123 - Adaptive Driving Beam)

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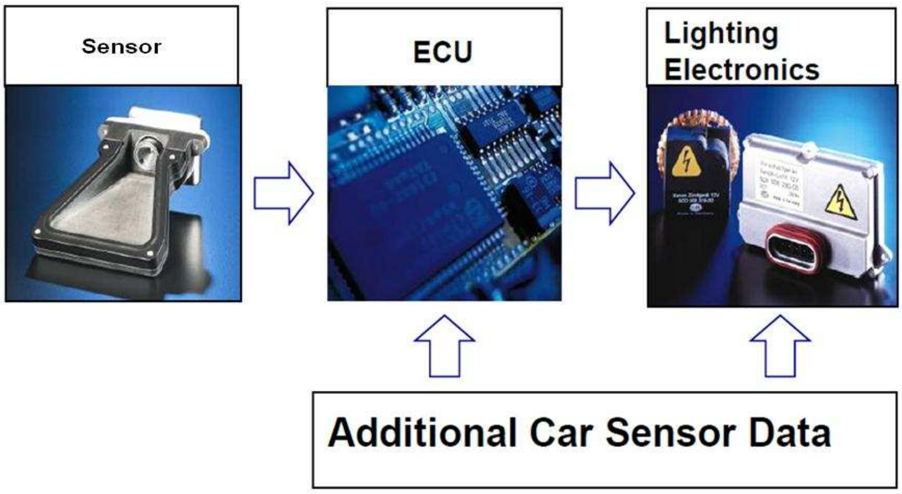
1. Technology Status

Currently there are three distinct technologies that have been developed:

(a) *Automatic Activation / Deactivation of the Main (Driving) Beam*

Type-approvals have already been granted by some administrations based upon interpretations of the existing provisions of R48. This system is now installed on many vehicles with no complaints from users or other road traffic.

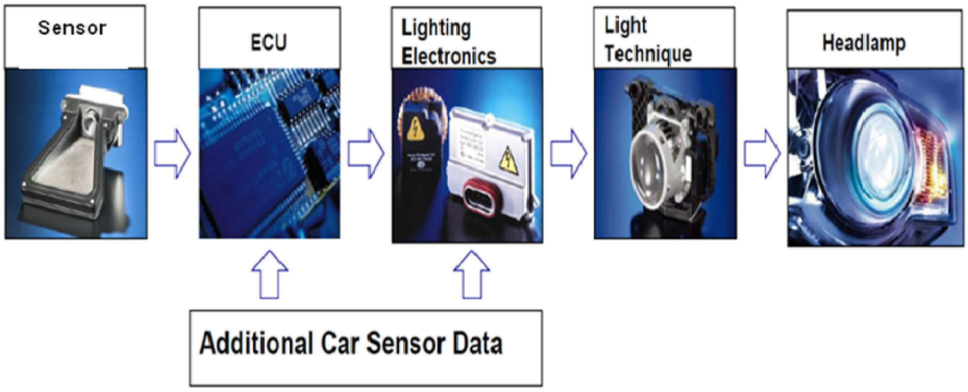
This system senses the presence of oncoming and preceding vehicles and automatically activates and deactivates the main beam. Signals are received from the sensor and processed by the Electronic Control Unit (ECU) that then transmits instructions to the lighting electronics.



Source: ISAL 2009, Paper A35.

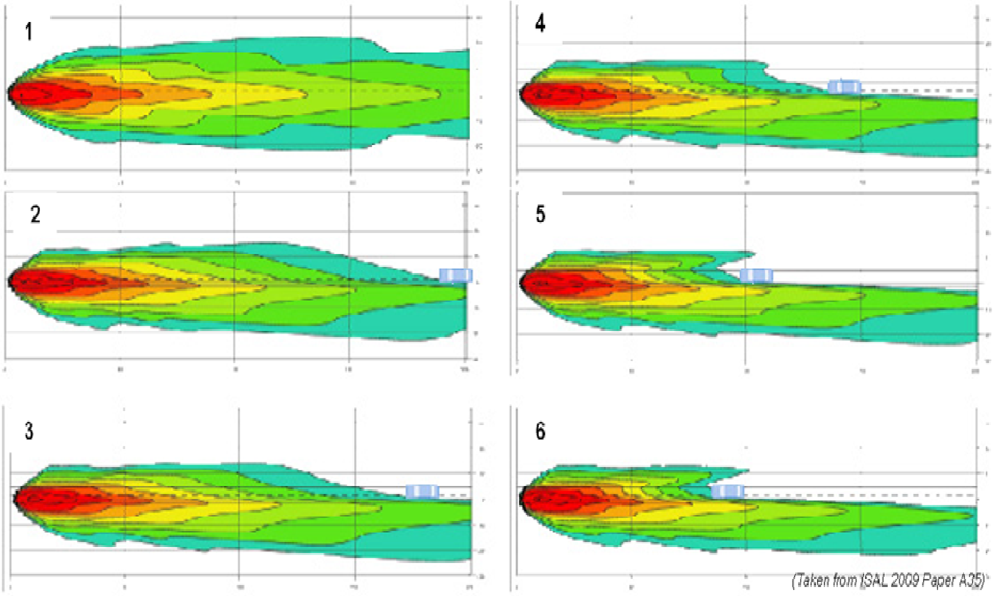
(b) Some vehicles have been type approved with these systems installed on the basis of interpretations of the existing AFS regulations. These systems are installed as optional equipment on vehicles sold world-wide based upon a high level of confidence of their safety and reliability by the vehicle manufacturers.

The Adaptive Dipped Beam Cut-off Line system is based upon a sensor that identifies the positions of other vehicles and an image processor and electronic control unit (ECU) sending signals to the headlamp that automatically adapts the dipped beam cut-off to provide optimised glare controlled illumination of the road scene ahead. This system is primarily moving the cut-off in a vertical direction.



Source: ISAL 2009, Paper A35.

The adaptation sequence (1–6) is shown below:

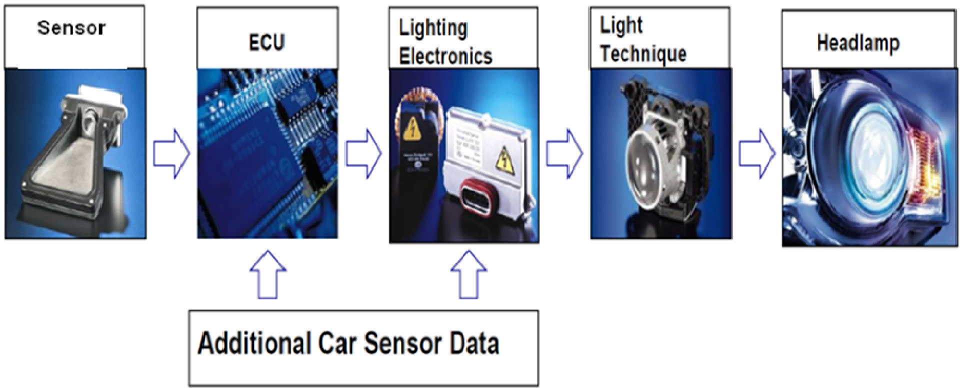


Source: ISAL 2009, Paper A35.

(c) *Adaptive Main (Driving) Beam*

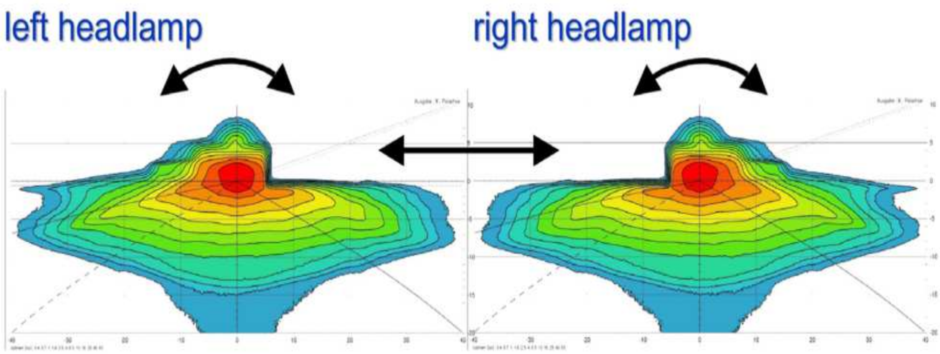
Systems have been fully developed and are ready for launch based upon a high level of confidence of vehicle manufacturers. However, they cannot be type approved according to the provisions in the existing AFS regulations and manufacturers are awaiting the adoption of amendments to Regulation No's 48 and 123 in order to launch this important new technology into the market.

The Adaptive Main Beam system is based upon a sensor that identifies the positions of other vehicles and an image processor and electronic control unit (ECU) sending signals to the headlamp that automatically adapts the light distribution of the main beam to provide optimised glare controlled illumination of the road scene ahead. The sensor, ECU and lighting electronics are similar to that used for the Adaptive Dipped Beam Cut-off Line system but the light technique and the headlamp construction differ to provide more flexibility in the way that the light distribution can be adapted both vertically and horizontally.



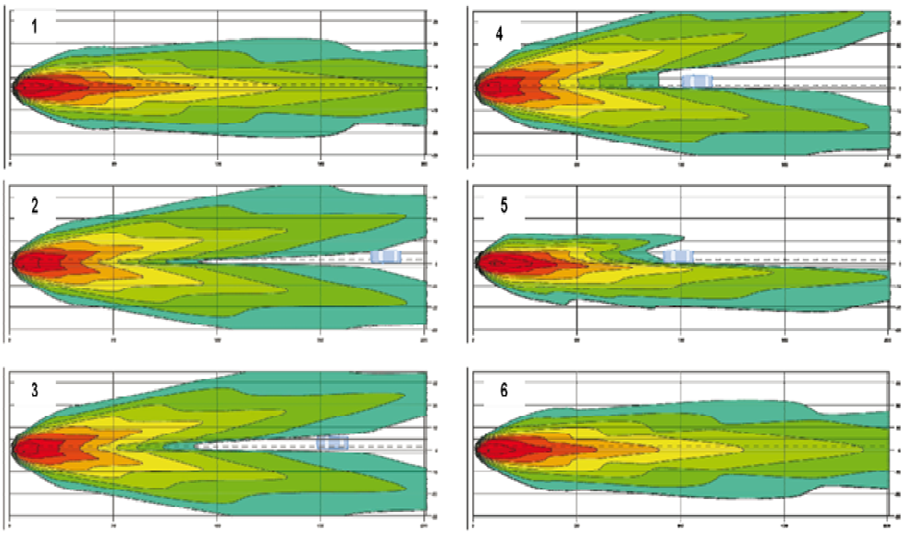
Source: ISAL 2009, Paper A35.

To provide the adaption of the main beam light distribution the optical components of the left-hand and right-hand headlamps are able to move independently as shown below:

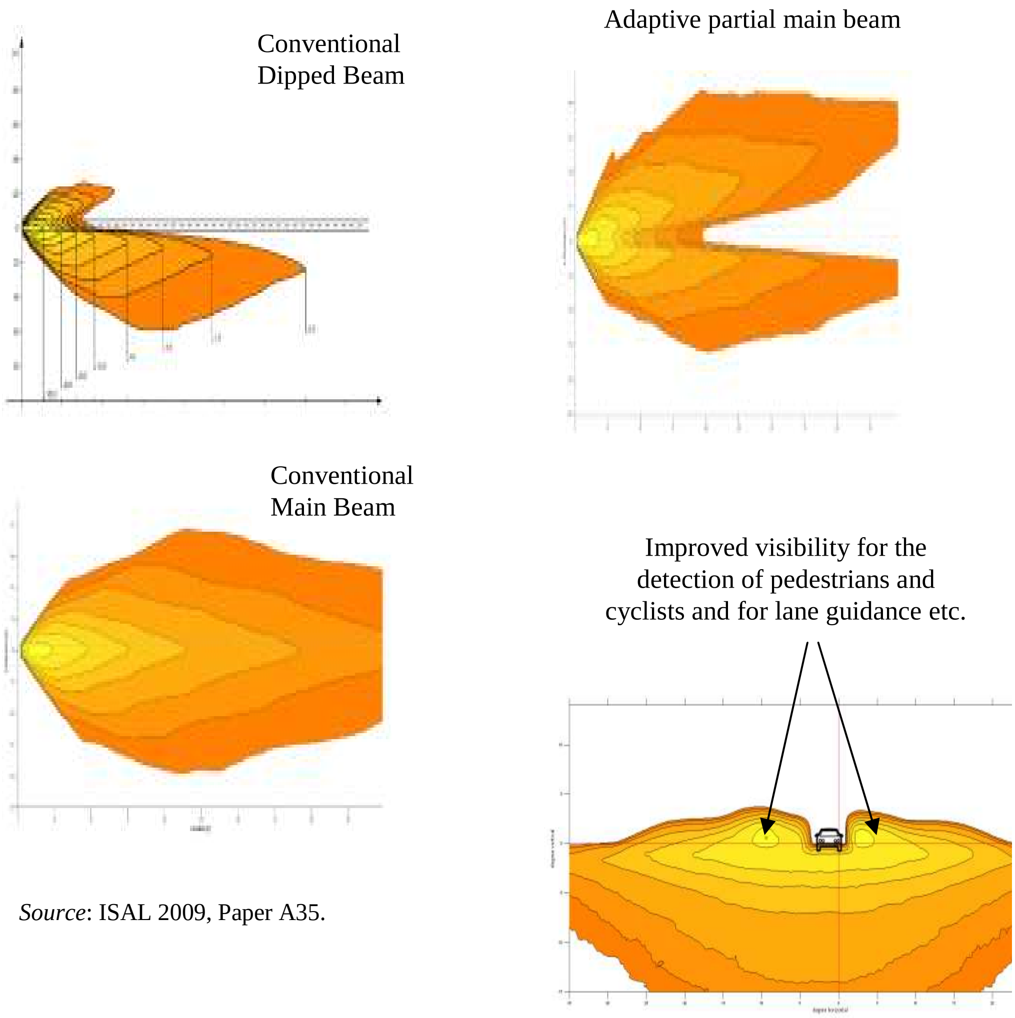


Source: ISAL 2009, Paper A35.

The adaptation sequence (1-6) is shown below:



Source: ISAL 2009, Paper A35.



Source: ISAL 2009, Paper A35.

The technologies described above will be installed initially on high range vehicles sold globally and some interpretations of the existing provisions of Regulation Nos. 48 and 123 have already allowed systems to be type approved. Manufacturers have launched these systems fully aware of their novelty and the impact of any failure or complaint from road users upon their brand-image and reputation. The Adaptive Main beam represents the first time that a headlighting system under automatic control has the potential to actively cause glare to opposing road users. So far, AFS systems have being restricted to varying the light distribution below the horizontal plane with minimal risk of causing glare disturbance.

In view of the novelty and the massive potential benefits to road safety of the Adaptive Main Beam system, manufacturers have invested in extensive development and proving programmes and have only taken the decision to launch it on their prestige vehicles after gaining a high level of confidence. Fully developed systems have been tested under real road conditions in Europe and USA over a period of two years and a distance of more than one million kilometres.

2. Safety Issues

(a) Optimised Use of Main Beam

The current main beam glares oncoming traffic in many situations and cannot be used whilst the separation distance between vehicles means that the dipped beam will often fail to provide sufficient forward illumination. Additionally, research confirms that drivers have a reluctance to operate the main beam and frequently select the dipped beam too early.

A report produced by UMTRI in 2006 investigating the “Real World Use of High-Beam Headlamps” concluded:

1. Report No. UMTRI-2006-11	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Real-World Use of High-Beam Headlamps		5. Report Date April 2006
		6. Performing Organization Code 302753
7. Author(s) Mefford, M.L., Flannagan, M.J., and Bogard, S.E.		8. Performing Organization Report No. UMTRI-2006-11
9. Performing Organization Name and Address The University of Michigan Transportation Research Institute 2901 Baxter Road Ann Arbor, Michigan 48109-2150 U.S.A.		10. Work Unit no. (TRAIS)
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address The University of Michigan Industry Affiliation Program for Human Factors in Transportation Safety		13. Type of Report and Period Covered
		14. Sponsoring Agency Code

[a] “While regional differences in high-beam use were observed, substantial underuse of high-beam headlamps was present in all areas of the country.

[b] In car-meeting scenarios, on average, drivers dimmed their high beams at an inter-car distance of 522 m.

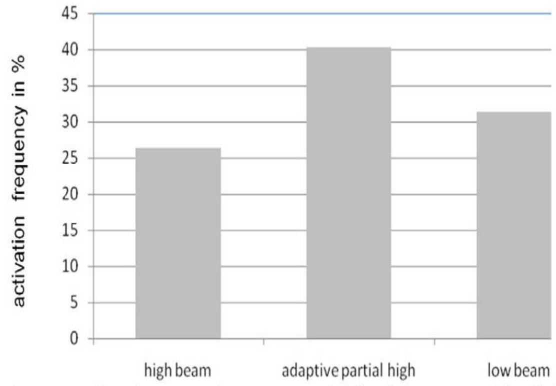
[c] From an obstacle detection standpoint, Helmers and Rumar *(1974) reported a distance of 250 m to 400 m as an optimal distance for switching from high to low beams.

[d] The dimming distances observed by Hare and Hemion were clearly substantially longer than is advisable for object detection and occurred at distances at which disability glare is not a factor.”

To achieve significant improvements in road safety it is clear that drivers will benefit from assistance with regard to switching from main beam to dipped beam. Technology that can adapt the main beam to traffic conditions will meet this requirement and also improve illumination between the dipped beam and main beam states.

In a paper presented to the ISAL 2009 symposium a report on recent research in Germany had clearly demonstrated the benefits of an adaptive main beam in terms of the relative frequency of its activation compared with conventional dipped and main beam.

* Professor *Kare Rumar* of the Swedish Road and Traffic. Research Institute.



: Distribution between low beam, adaptive partial high beam and high beam on country roads and motorways over all test runs

	distance / km	share
town	54	7,8 %
country	422	61,2 %
motorway	213	31,0 %

Source: ISAL 2009, Paper A35.

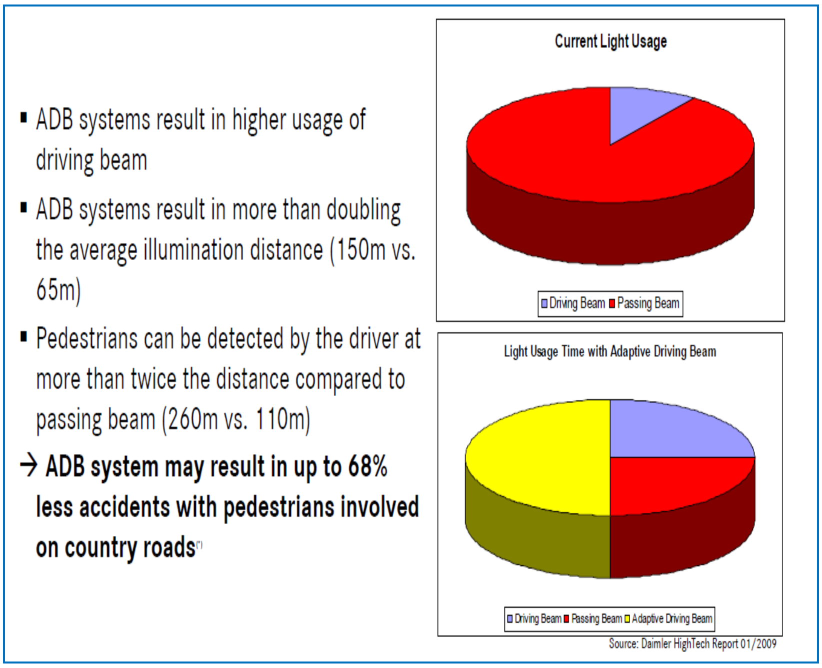
It should be emphasised that whilst the driver assistance systems for the optimised use of the main beam reduce driver fatigue through improved visibility and by reducing the work load, the driver remains responsible for deciding when it is appropriate to use the main beam and when to switch to dipped beam.

(b) *Enhanced Detection of Pedestrians*

Night-time Pedestrian fatalities continue to be a major safety issue throughout the world and, whilst encouraging reductions are resulting from measures being taken by many governments, it is clear that vehicle headlighting can play a major role in achieving significant reductions.

The SAE Information Report J2829 produced in conjunction with GTB and CIE identifies minimum requirements for the detection of pedestrians and shows that in many cases the dipped beam is incapable of providing sufficient visibility. It further concludes that efforts to improve vehicle lighting standards are clearly required.

At the ISAL 2009 symposium the following was also reported based upon research into the benefits of Adaptive Main Beam systems.



Source: ISAL 2009, Paper A35

(c) *Enhanced Detection of Bicycles*

This subject was strongly debated during the GTB Working Group meetings and much consideration was given to the special circumstances existing in the Netherlands where bicycle accidents are a major issue.

There are many concerns relating to the safety of cyclists due to poor or no lighting on the cycle and no standard cycle lighting performance. There are also many complaints from cyclists that they are disturbed by the glare from oncoming vehicles. Compounded with this is also a high incidence of cycle crashes where another vehicle is not involved so it is difficult to determine the negative impact of potentially higher glare from adaptive main beam systems that have failed to detect a cyclist. However, in the case of cycles not having good lighting it is clearly preferable for a driver to be able to recognise them through the use of the main beam even at the risk of causing some glare discomfort. Cycles equipped with good lighting will be detected by the system which will react and adapt the main beam to avoid causing discomfort.

3. The Regulatory Challenge

The introduction of systems incorporating software that interprets the traffic and road scene conditions to decide how to automatically adapt the light distribution of the headlamp is a matter that has not been previously confronted at GRE level. Whilst the sensor systems and the headlamp optical arrangement can be validated by the familiar type approval system, an approach has to be developed to validate the performance and reliability of the control software.

Manufacturers have extensive experience with sensor systems on vehicles.

Objective performance specifications are well established

Image processing and generation of appropriate control signals is based upon algorithms developed by the vehicle manufacturer in conjunction with suppliers. These algorithms are the result of extensive testing in real-world conditions.

Objective performance specifications are difficult to prescribe.

Lighting electronics, optical techniques and headlamp construction technology are all well developed based upon AFS experience.

Objective performance specifications are well established

The regulatory challenge is therefore:

(i) How to introduce objective requirements into the regulations to assure safety and avoidance of complaints from other road users

(ii) How to produce requirements that are technology independent, can be verified during type approval and include measures to validate the effectiveness of the software

4. Proposals for Amendments

The following is an overview of the main points incorporated into the proposed amendments to the regulations; ECE/TRANS/WP29/GRE/2010/40, ECE/TRANS/WP29/GRE/2010/41 and ECE/TRANS/WP29/GRE/2010/42.

(a) Definition of Adaptive Main Beam

"*Adaptive main-beam*" means a main-beam of the AFS that adapts its beam pattern to the presence of oncoming and preceding vehicles in order to improve long-range visibility for the driver without causing discomfort, distraction or glare to other road users.

Although not included in the definition, the amendments have been based upon the principle that although the driver assistance systems for the optimised use of the main beam reduce driver fatigue through improved visibility and by reducing the work load, the driver remains at all times responsible for deciding when it is appropriate to use the main beam and when to switch to dipped beam..

(b) *Sensor Requirements*

The sensor requirements have been defined to take account of the following conditions:

(i) ambient lighting;

(ii) the light emitted by the front lighting devices and front light-signalling devices of oncoming vehicles;

(iii) the light reflected from front retro-reflecting devices of oncoming vehicles

(iv) the light emitted by the rear light-signalling devices of preceding vehicles;

(v) the light reflected from rear retro- reflecting devices of preceding vehicles.

The definition of vehicles includes categories L, M, N, O, T, as well as cycles, being equipped with retro-reflectors and with lighting and light-signalling devices, which are switched ON.

It was concluded that the same requirements shall apply to all technologies (Automatic activation / deactivation and adaptive).

(c) *Minimum detection angles*

This subject was carefully considered because it has a major impact upon the overall performance of the systems. Obviously, a small detection angle will result in the system only reacting to part of the traffic in the road scene with serious glare consequences. Conversely, a large angle will reduce the sensitivity of the system resulting is a failure to detect other vehicles at longer distances or a high incidence of incorrect activations.

It was concluded that the requirement should be as follows:

i Horizontal angles: 15° to the left and 15° to the right.

ii Horizontal angles: 5° up and 5° down (depending upon the mounting height of the sensor).

These angles will assure that the sensor will accommodate a 5 per cent gradient and a 420m radius (left and right) horizontal curvature of the road.

(d) *Minimum detection distance*

The choice of the minimum detection distance of the sensor will also have a major impact upon its sensitivity and the consequent risk of false reactions. The minimum detection distance is influenced by the intensity of the approaching light source to be detected and by the ability of differentiate between moving and stationary objects.

The research carried out by UMTRI and reported in UMTRI-2006-11 concluded:

1. Report No. UMTRI-2006-11	2. Government Accession No.	3. Recipient's Catalog No.
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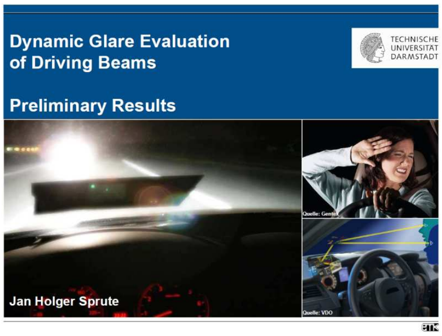
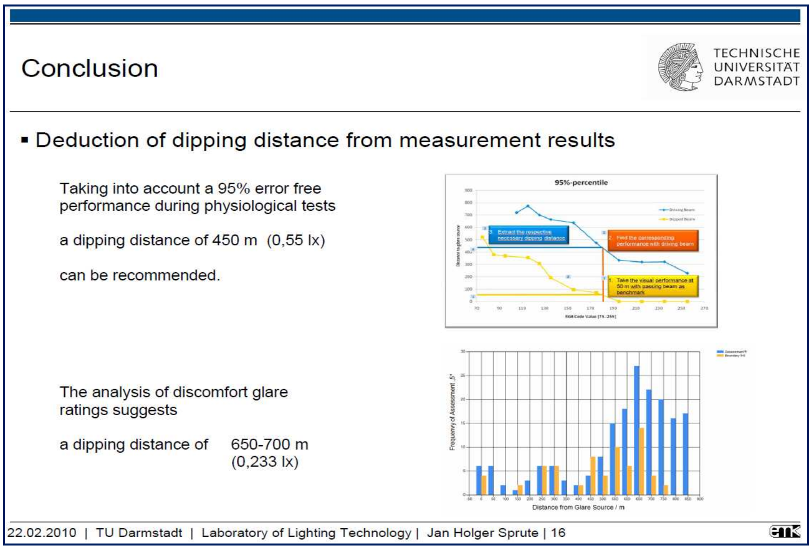
12. Sponsoring Agency Name and Address The University of Michigan Industry Affiliation Program for Human Factors in Transportation Safety		13. Type of Report and Period Covered 14. Sponsoring Agency Code

[a] "From an obstacle detection standpoint, Helmers and Rumar**(1974) reported a distance of 250 m to 400 m as an optimal distance for switching from high to low beams."

[b] An interim report on research being carried out by Technical University – Darmstadt suggests that "Taking into account a 95% error free performance during physiological tests, a dipping distance of 450m (0.55 lx) can be recommended"





** Professor *Kare Rumar* of the Swedish Road and Traffic. Research Institute

The Darmstadt report also carried out an analysis of discomfort glare ratings that suggested a dipping distance of 650-700m but it was decided that, as the research had not been designed specifically for the question of the minimum detection distance in the context of the Adaptive Main Beam system, these values would be disregarded until more research is available.

The challenge for the system designers is to differentiate between oncoming vehicles and the road infrastructure, especially red and white retro reflecting devices. Setting a long detection range for oncoming vehicles will reduce the reliability of the system because it will not differentiate between moving and stationary objects. Setting a low detection range for bicycles may result disproportionately in an increased number of false main beam turn-offs because the system will not be able to differentiate between a cycle light and the reflection from a marker at the side of the roadway.

Driver acceptance of ADB systems is based on correct performance with minimisation of false main beam turn-offs and accurate reaction to clearly visible, self illuminated road users.

The above photographs illustrate the difficulties encountered by the system to distinguish moving traffic from road signs etc.

In conclusion the following requirements were adopted:

“The sensor system shall be able to detect on a straight level road:

(a) an oncoming power driven vehicle at a distance extending to at least 400 m;

(b) a preceding power driven vehicle or a vehicle-trailers combination at a distance extending to at least 100 m;

(c) an oncoming bicycle at a distance extending to at least 75 m, its illumination represented by a white lamp with a luminous intensity of 150cd with a light emitting area of $10cm^2$ +/- $3cm^2$ and a height above a ground of 0.8m. “

Note: As no international standard exists for the photometric characteristics of a cycle lamp the working group decided to introduce a performance definition that could be used as a basis for the type approval testing.

(e) Correct reaction of the headlamp to the control signals

Photometric requirements have been introduced into Regulation No. 123 for the verification of the correct reaction of the headlamp to the control signals. The applicant will provide a suitable signal generator for use by the test laboratory to check the performance under the different simulated traffic conditions.

Provisions for the right hand or left hand traffic are included.

(f) *Performance verification*

In order to verify the correct generation of the control signals, a requirement for the authority responsible for type approval testing to carry out a test drive is detailed in the annex 13. This specifies objective requirements that are to be carried out and reported. There are also requirements for the applicant to provide evidence of simulation or other means of verification of the system. This follows a similar practice to that adopted in Regulation 13, annex 18.

5. Summary of GTB / GRE activity

The GTB Working Group has held nine meetings between May 2008 and May 2010 and has benefited from the constructive participation of GRE experts. In addition the following activities have taken place:

GRE 60th session (October 2008)

- Presentation of the concept and demonstration of prototypes
- Informal document “Presentation by GTB – AFS main beam (driving beam) improvements”.

GRE 62nd session (October 2009)

- Formal proposals to amend Regulations 48 and 123 with accompanying presentation
- (ECE/TRANS/WP.29/GRE/2009/56) / (ECE/TRANS/WP.29/GRE/2009/57)
- (ECE/TRANS/WP.29/GRE/2009/59)
- (GRE-62-05) (GRE-62-13) (GRE-62-14) (GRE-62-16) (GRE-62-17) (GRE-62-18), (GRE-62-19) (GRE-62-20) (GRE-62-21)

GRE 63rd session (March 2010)

- Progress report and discussion of open issues
- GRE-63-21 Presentation
- GRE-63-20 Basis of open discussion

Night Drive of systems in the Geneva region

- GRE-63 informal document “OICA CLEPA ADB Demonstration”

GTB Night Drive- Arnhem, NL- 01 June 2010

- Supported by vehicle and headlamp manufacturers
- 40 participants and eight test vehicles

6. Conclusion

Throughout the duration of the GTB working group it has been very evident that there has been significant improvement in the performance and reliability of the various technologies that are already on the market and performing satisfactorily or are fully developed and awaiting the amendments to the regulations to allow their launch,

The amendments proposed complete the Adaptive Forward Lighting System concept and promise significant improvements to road safety. The availability of a complete adaptive system, dipped beam and main beam, is likely to increase the take-up of these technologies and result in improved headlighting performance. Additionally, the function of the “Main Beam Driver Assistant”, either the automatic activation and deactivation or the fully adaptive technologies, will encourage optimised use of the main beam with its obvious safety benefits that have been identified by many researchers over decades.

A solution has been found for the verification of the system control software using a combination of information from the manufacturer and test drives by the technical services. The objective requirements introduced into the regulations are based upon the best knowledge and experience of GTB and GRE experts and whilst in some case are compromises taking into accounts limitations in the current state of the technologies but also acknowledging the potential safety benefits.

Finally, it should be remembered that these proposals relate to technologies providing a driver assistance system. It is emphasised that the driver remains responsible for correct use of the systems at all time.