
SIA Vision Congress

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INTRODUCTION

The 2018 VISION congress—**Vehicle and Infrastructure Safety Improvement in Adverse Conditions**—was held in Paris on 9 and 10 October at La Cité des Sciences de la Villette, a place totally dedicated to technologies, a strong example for the vehicle lighting community; especially young engineers and universities.



This biennial international congress organised and presented by SIA (the French Society of Automotive Engineers) was first held in 2002 and has been steadily growing ever since, with record participation of 550 attendees in 2016, up 20% from 2014. This year, more than six hundred attendees are expected.

	2002	2004	2006	2008	2010	2012	2014	2016	2018
Attendees	90	130	160	160	230	330	440	550	610
Demo-cars	7	9	11	10	16	20	24	24	31

VISION is a forum geared toward informational exchange amongst top-level scientists, engineers, and practitioners; directors, managers, department heads, and experts from industry, universities, and research centres. Its characteristic centrepiece is night drives with at least 30 different demonstrator cars carrying groups of participants around the Mortefontaine race track to show off the real-world function of the latest innovations in lighting, driver assistance, and autonomous capability. Moreover, there are networking opportunities for attendees and speakers, with a large-scale expo hall covering a wide range of products and services in the field of lighting, ADAS, and autonomy.

The round table at the end of the congress, with the greatest experts of lighting and ADAS was a great moment. They offer to the attendees several ways to combine lighting and ADAS. The main conclusion: Lighting needs ADAS to lead the intelligent lighting and ADAS needs Lighting to help visibility of sensors and to fit in the future camera and lidar inside the headlamp

The Best Lectures at VISION



Michael Kruppa is honoured to be the recipient of the Best lecture at the VISION congress.

He is, since 2016, head of tail light development at Audi.

His lecture **An OLED Tailight Revolution**, showed that OLED is ready for automotive. the light revolution has just started and the substitution of LEDs by OLEDs will lead the future for tail lighting.



Just behind, at the same level, Paul-Henri Matha, and Hassan Koulouh/Ulrike Geissler. In his lecture, **Full LED Headlamp gen3**, Matha presented the works Renault team has done on LED headlamp about cost optimization thanks Standardization of LED ECU and LED module, a very skilled team with *Optical, LED, Hardware, Mechanical, System engineers, a talented project leader*, and a close collaboration with Tier1 Hella, AL, and Osram-Continental, Nichia, Lumileds.



In their lecture, **Active Moisture removal**, Hassan Koulouh and Ulrike Geissler showed how we can actively prevent condensation and put headlamps on a new level of protection. AML's Condensation Management Device (CMD) enabled by GORE leverages electrical power and regenerative desiccants to actively remove recurring moisture from automotive headlamps.

To close the Top 5, We have to mention **AL's Ernt-Olaf Rosenhahn**, and **Lumileds's Helmut Tiesler-Wittig**.

EXECUTIVE SUMMARY



VISION congress was held on 9-10 October in Paris, Cité des Sciences and in Mortefontaine for the night drives.

Highlights of VISION included:

- 1) More than 600 attendees from 125 worldwide companies
- 2) the three best lectures :
 - An OLED Taillight Revolution from Michael Kruppa, head of tail light development at Audi.
 - Full LED Headlamp gen3, from Paul-Henri Matha, now at Volvo Motors
 - Active Moisture removal from Hassan Koulouh and Ulrike Geissler and the two other AL's Ernt-Olaf Rosenhahn, and Lumileds's Helmut Tiesler-Wittig.
- 3) Wonderful expo booths of big, small, and startup companies in optics, electronics, and simulations.
The 26 exhibitors focussed on improved safety now available in passenger cars thanks to digital lighting, and on improved comfort brought by ADAS.
- 4) Night demo drives with 31 cars showing the latest technologies in Lighting and in ADAS.
- 5) The panel discussion with great minds in lighting and ADAS. What a great moment, with passionate discussion about ways of combining lighting and ADAS. The main conclusion: lighting needs ADAS to lead the intelligent lighting, and ADAS needs lighting to aid visibility of sensors and integrate cameras and lidars inside the headlamp. I thank again all the people who helped to make such a grand success of this event.

GENERAL TOPICS

Chairman : Michael Hamm, Audi

Full LED headlamp Gen3 : How Renault continues to reduce cost and increase performance

Paul-Henri MATHA, Renault

Assistance System for Vehicle-Pedestrian-Interaction

Johannes RESCHKE, AUDI

A Development of LED Headlamp Module for Cost Innovation

Gil-won JEONG, Hyundai Mobis

Full LED Headlamp Gen. 3: How Renault continues to reduce cost and increase performance

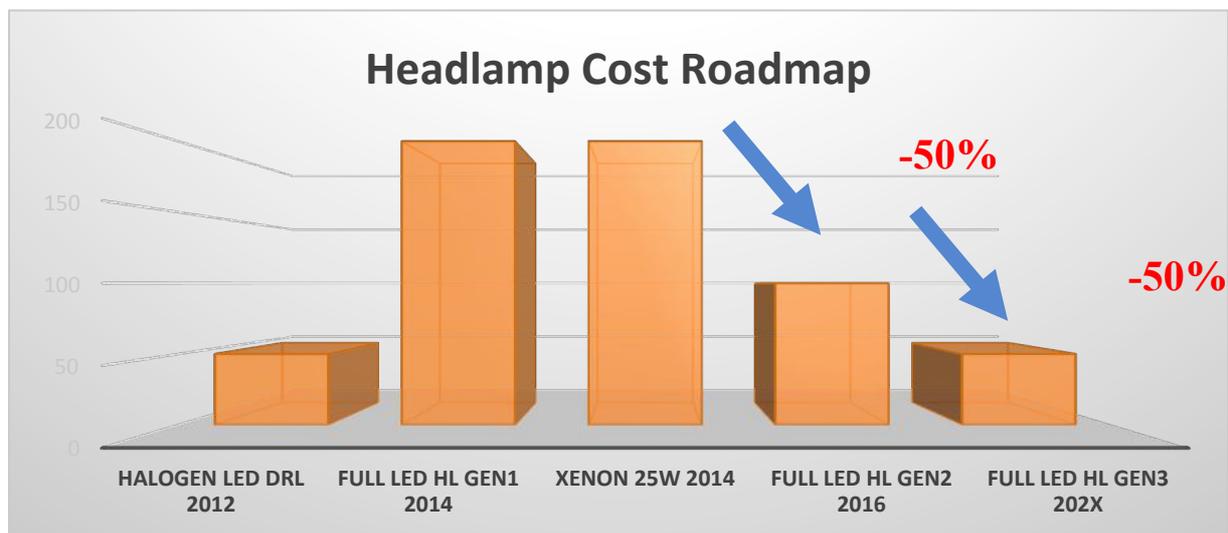
Paul-Henri Matha, Annie Blondel - Renault S.A.

Renault was targeting low cost for LED headlamp since many years, and particularly full LEDs headlamps able to compete in cost with halogen + LED DRL.

A first generation developed in 2014 was already competitive with Xenon 25W, but significantly more expensive than the halogen reference.

The generation 2 launched in 2016 reduced the cost by 50%. It is now installed on several B & C segments cars and thanks to its cost is allowing some Renault cars as Captur to have currently a take rate of 50% with LEDs.

A third generation is now developed with a complementary cost reduction of 50% thanks to a strong standardization.



The main parts of the cost were in the optical module for 35%, in the LED ECU for 10%, and in the height sensor for 10%: these parts have been so the main support for cost reduction.

LED ECU: A standard ECU is now equipping 13 cars, and 11 additional projects will receive this ECU.

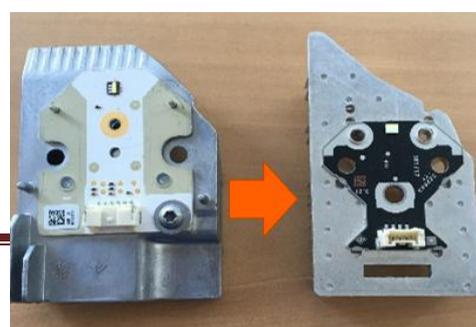
3 million ECU units will be produced in 2018 both for Renault and Nissan.

Technically, the ECU is including only one boost, one Rbin and one NTC for LB and HB. It can manage a wide range of current and voltage with a maximum power of 54W.

The optical module has for key cost inductors the LEDs for 33%, the heatsink for 17% and the PCB for 17%.

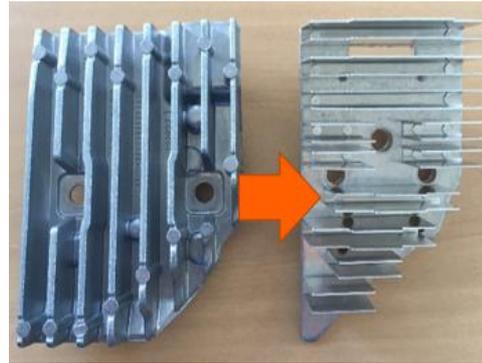
- For the LEDs, between gen.1 and gen.2, the current was increased from 1A to 1,2A with an evolution of the flux from 270lm to 360lm while the junction temperature was decreased from 130°C to 100°C.

- The PCB was optimized with a size reduction of 30%

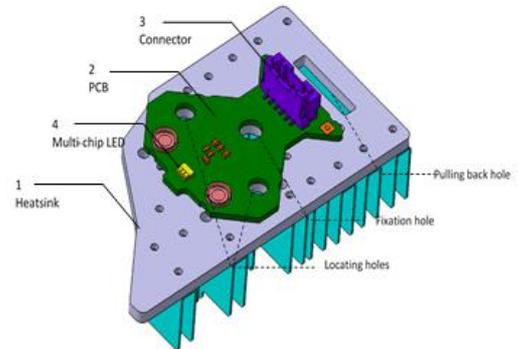


- The heatsink was optimized with a weight reduction of 50%
- . With LED Rth improvement
- . And PCB Rth improvement

Thanks to a better thermal simulation in static and dynamic conditions with FloEFD software

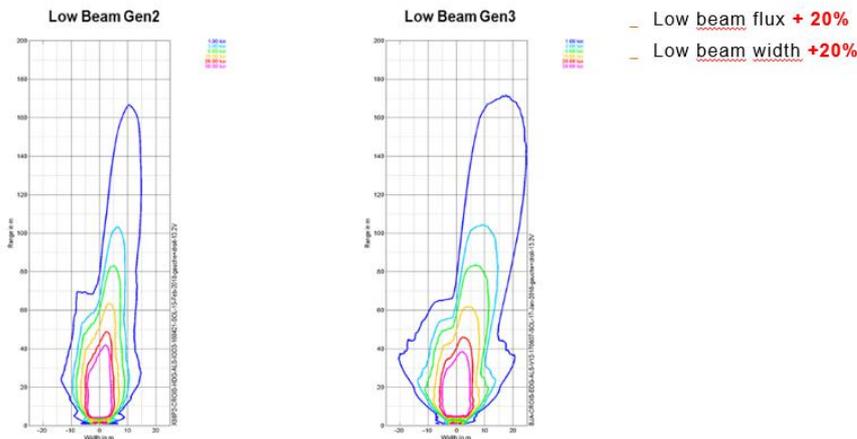


The new paradigm of Renault is so the use of a standard LED module on all Renault headlamps with the standard Renault ECU compatible with all headlamp set makers.



Standard LED module (named **LSU** for light source unit)

About **photometric performances**, the generation 3 improved Low beam performances by +20% for flux and width. The range of the high beam was also improved by 20%.



Conclusion

Renault is considering this development as a success thanks to a good team and a good collaboration with tier 2 and tier 3 suppliers. This standardization by the car maker is interesting as it was pushed at a maximum level. There are certainly as always with standardization profits for development, validation costs and maintenance. However, the optimization of the cost for every application could perhaps be challenged.

Assistance System for Vehicle-Pedestrian-Interaction Deep Learning and Driver Intention Prediction

Johannes RESCHKE, AUDI AG

Johannes Reschke first demonstrated the interest of a good interaction between the vehicle and pedestrians.

The three main reasons are:

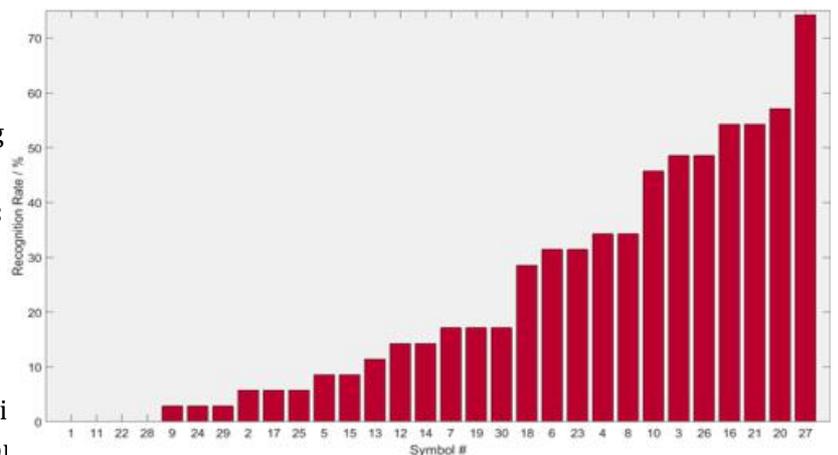
- Pedestrians feel safe when interacting with the driver
- Solving unclear situations
- No confusion about the situation, especially with limited visibility

But symbols for this interaction needs to be intuitive.

30 symbols were analysed with 35 participants in 4 tests.

The main results were that:

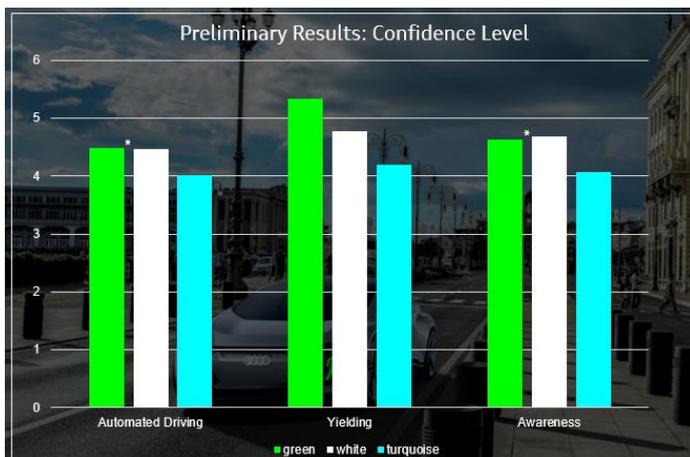
- Blocks are hardly recognized
- Dynamic Symbols make sense for Dynamic Situations
- There is a large difference of recognition rate between the symbols from 3% to more than 70%
- And with a large difference of time for interpretation,
 - The mean interpretation time for all symbols being at 6,6 s for intuitive symbol (with no previous information given) and 2,8 s with correlation (information given previously)
 - The mean interpretation time approach and 1,5s with correlation



A complementary test was done with 3 situations, 6 colors, 9 symbols and with 709 participants.

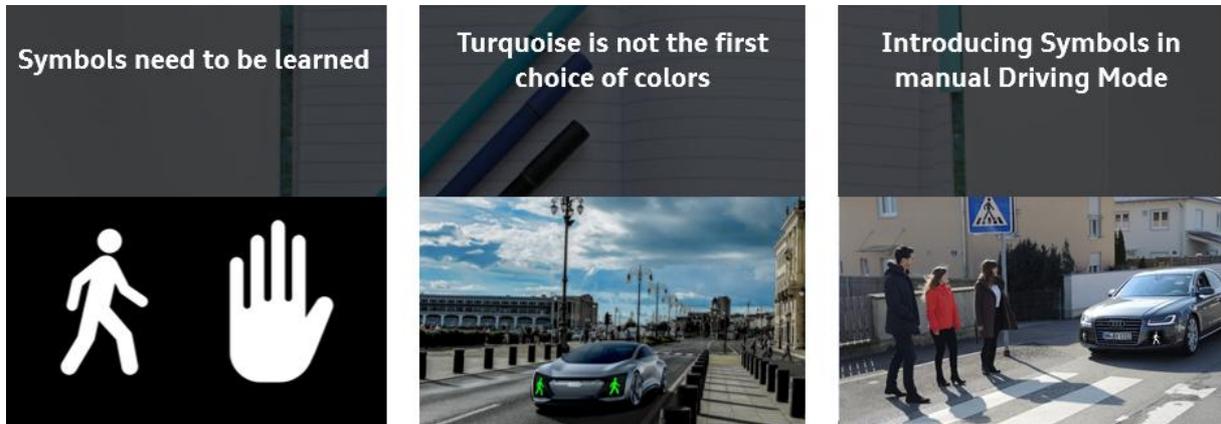
It appeared that turquoise is not a good choice for the color, green and white being better.

For the situations, a zebra crossing was particularly considered.



The analysis was also done thanks to a deep learning system (part of machine learning being itself part of Artificial Intelligence) to predict the recognition of symbols.

Conclusion:

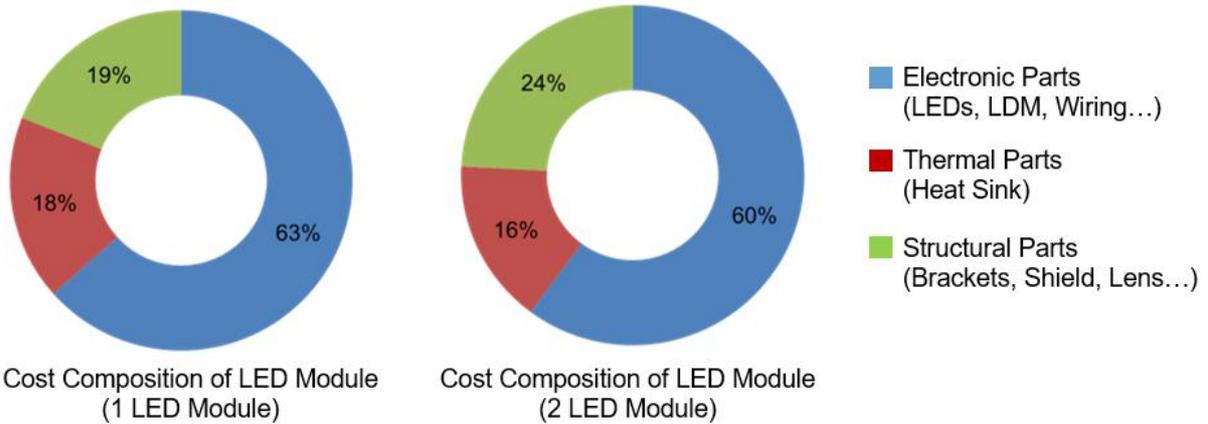


- The symbols even the most intuitive are recognized in a too long time if not learned before → the symbols will have to be learned
- The symbols will have to be introduced in manual mode to be better understood and learned
- Turquoise is not a good color, green or white being the best
- The approach with a machine learned algorithm to detect the driver's intention is interesting to obtain quicker and more reliable results. It will have for that to use more training data.

Research of LED Headlamp Module for Cost Innovation

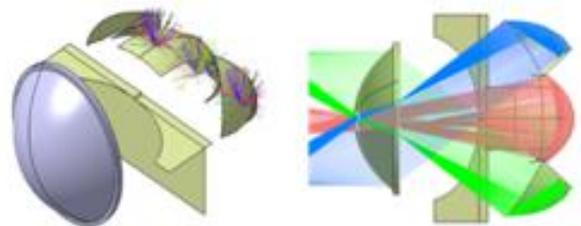
Gil-won Han & Emanuel Kurek, Hyundai Mobis

For cost reduction of LED systems, Electronics parts have to be considered in priority as they are the main part of the global cost.



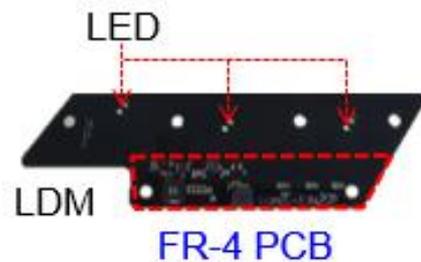
For cost reduction, 4 main directions were considered:

- **LEDs separation:** LEDs are in separate location so each Led in a specific reflector, this authorizi more simple and less expensive thermal management



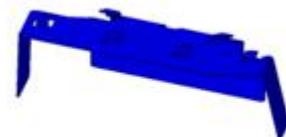
[Proposal Structure]

- **The LEDs and the driver are on the same PCB,** eliminating the need of the intermediate wire. A new material for the PCB was developed improving the thermal resistance from 100% to 30%

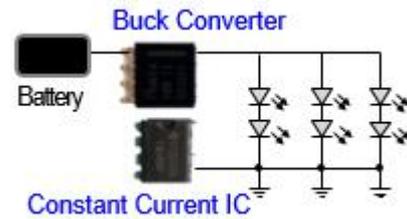


[Proposal Structure]

- **A new AL plate heatsink** was developed replacing the traditional die cast heatsink with a reduction of weight of 50%

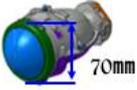
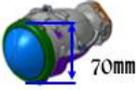


- **The LDM (LED Driving Module)** was simplified the traditional driver IC being replaced by more simple buck converters. The number of elements was increased, but the price was decreased by 30%



Thanks to this development, a complete line of new modules (reflector type, projector type or bi-function projector type) was developed allowing a reduction of height of the optical systems from 70mm with halogen to 55mm with LEDs.

The target here is to replace halogen by a LED headlamp having a similar level of performances and with currently an on cost limited at 50%

		Halogen Module		Proposal LED Module		
		Projection	Bi-function Projection	Reflector (MFR)	Projection	Bi-function Projection
Image						
Road Per.	Distance	89.2M	102.2m	98.5M	117.2M	106.3m
	Width	21.4M	20.4m	21.3M	20.6M	18.1m

Conclusion

This presentation shows that the replacement of halogen by LEDs for headlamps is on a good way. For mainstream applications, cost is naturally a very important driver for the choice and the kind of solution shown by Mobis is demonstrating that the current on cost for LEDs compared to halogen is now becoming acceptable in front of the numerous advantages of this technology particularly for style.

SIGNAL TECHNOLOGY

Chairman : Jean-François Dacquay, Renault

Influence of new signal lamps for automated vehicles on other road users - Can virtual reality be used to investigate the behaviour of pedestrians ?

Timo SINGER, TU Darmstadt

Merging Lighting & Sensing, a new path toward more automated vehicles

Benoit REISS, Joachim Mathes, Valeo

An OLED Taillight Revolution - From Point Light Sources to Area Light Sources

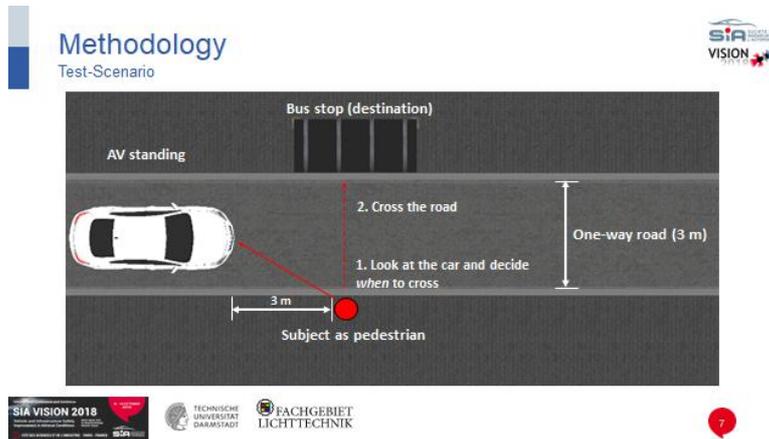
Michael KRUPPA, AUDI

Influence of new signal lamps for automated vehicles on other road users

Timo SINGER, TU Darmstadt

To answer to one of the main questions with Autonomous Vehicle: What needs to be signaled and when? Can we use Virtual Reality to study the long list of scenarios/ behavior of other road users confronted with AV?

The following virtual scenario has been built to test different signal displayed on the front of the car:



The benefits of working in Virtual reality are:

- Virtual complex traffic scenarios can be implemented and subject can move “freely”
- Perception studies in pedestrian “point of view”
- Repeatable studies realizable, time/weather/season independent
- Animation and design aspects can be implemented (understanding of signals)

The simulated test car allows six different light signals with different variations. They are composed of different moving behaviors of the car, combinations of different signals and different animation times.



Test has been run with 20 subjects male and female between 20 and 45 years old

Results:

- Demonstrated that Virtual Reality can be used for this type of test. Most subjects felt as pedestrians. Objects and parameters in virtual scene are rated as realistic.
- Rating of additional Lights:
 - Countdown and arrow have been rated best at all questions.
 - No clear difference between chaser signals.
 - Circle rated worst
- Crossing Behavior:
 - Over 90% of crossing decision in front of the car when 9s abstract animation (chaser light) or 6s specific animation (count down) are used
 - Between 30%-40% of crossing in front with 3s abstract signal
 - Small amount of crossing at hand symbol (13%) decreased with number of rounds (learning effect)

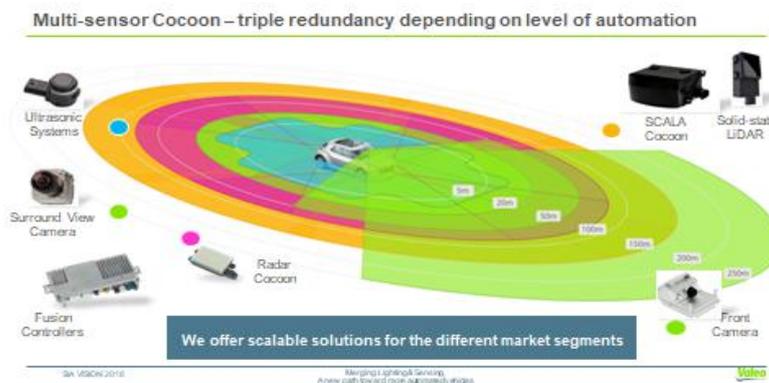
Conclusion

Virtual Reality is a must to test all different scenarios in a limited time frame and represent a good realistic representation of what happen in real life. It allows on top to test the scenarios in a safe environment for the subjects. Understanding of added signals with autonomous cars is key and standard, comprehensive and international signal needs to be defined quickly.

Merging Lighting & Sensing, a new path toward more automated vehicles

Benoit REISS, Joachim Mathes, Valeo

Autonomous Driving Cars needs a lot of different sensors to be able to operate properly. The chart below represents the operation domain of these sensors.



Some of these sensors need to be located on top of the car some others on the different side of the cars. Front camera behind the windshield for driver point of view and windshield cleaning, corner radars in bumper/fascia or headlamps/taillamps, camera cocoon in pod-like position above the waistline, in Grill, mirrors and handle/Chmsl or Headlamps/rearlamps, scala (scanning laser) cocoon in bumper/fascia or headlamps/taillamps

In order to reduce complexity of packaging, integration in Headlamps and Rearlamps needs to be considered.

What are the benefits and challenges to this integration?

- Common location at waist level
- Sensors can be seen as additional lighting module
- Product integrity including leveling functions for sensors
- Protection vs environment with sealed thermoplastic envelop
- Compatible with sensor cleaning system
- Electronic system architecture with data fusion and integration of EMI aspects
- Simplified industrial process at OEM

The planned evolutions of Lighting need to consider further integration and to go to merge Lighting and Sensing

Merging Lighting and cameras: Integration of short range cameras used for parking and maneuvering is feasible. Also, the possibility of common projection objective if field of view compatibility between HD lighting and camera sensor seems interesting to consider.

Merging Lighting and Radars: Merging electronic blocks like power module and picture control module. Limitation to the thickness of polycarbonate lens due to losses on radar signal.

Merging Lighting and Lidars: Possibility to combine IR illuminator with NIR Lidar, with visible light lidars: potential use of blue from white peak LED

Conclusion

Interesting study showing that lamps seem well suited to integrate needed sensors for autonomous vehicle and merge lighting and sensing to optimize cost and volume.

An OLED Tailight Revolution - From Point Light Sources to Area Light Sources

Michael KRUPPA, AUDI

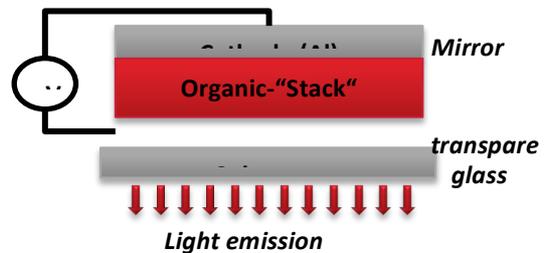
Since 2016 OLED technology are applied in automotive tail lamp applications

OLED properties: Best in class homogeneity, thinnest automotive light source, better efficiency than LEDs, unique very sharp contrast ratio allowing creating unique design possibilities.

Audi A8 tail lamp



OLED principle



Main challenges to overcome to use OLED technology: **Ageing, temperature and UV behavior**

- Thin film encapsulation allowed preventing aging of the quite sensitive organic materials and overcome moisture penetration, high-temperature and UV driven organic degradation.
- Fine tuning of supplier specific manufacturing parameters needed during design specific project approaches
- Discussions and technical alignment between OEM and Tier2 suppliers were demanded to successfully qualify OLEDs

Comparison test between LED homogeneous lamp with 16 Osram TopLED LEDs and OLED lamp showed higher uniformity and reduced power consumption in the OLED lamp. Increasing the uniformity of the LED based solution show a significant luminance drop of the simulated systems. On top of this within the used OLED package no LED solution with the required optical efficiency was possible.

The following path has been already identified to reduce drastically the cost:

- Yield improvement at supplier
- Design Hybrid OLED/LED lamps
- Design to optimize cost between costly large parts and high number of cheaper small parts
- Optimize OLED glass substrates
- Align supplier specific design guidelines maximizing substrate usage.

Doing all these recommendations we can expect a cost reduction by a factor 3 to 5.

Audi will define standards to lead to module based approaches in order to get economy of scales with an objective to get a **cost decrease factor over 10** by the year 2020 to 2025.

Main suppliers being OLED works and LG display in the future. Audi is planning introduction of OLED technology on 2020 and 2021 model cars with volume higher than 100 000 vehicles per model

Technology evaluates in 2 main directions: Increase Brightness to allow 12000 and even 50000 cd/m² going first to CHMSL, then Brake lamps, and then direction Indicator, and Massively increase the number of segments to allow exterior communication

Conclusion

The introduction of new light source has been always difficult. But when the technology proved to be reliable, volume start increasing while cost decrease allowing a better spread among the range of cars. One of the best lectures.

HEAD-LAMP TECHNOLOGY

Chairman : Kamislav Fadel , Hella

Invisible headlamps - micro lens array based front lighting

Benjamin WILLEKE, HELLA

Micro-optical Headlamp

Peter SCHREIBER, Fraunhofer IOF

Technological and physiological analysis of novel projection systems in automotive

Christopher BREMER, BMW

Illumination vs. Visualization in Headlamps: Way towards HD light source requirements

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Active condensation removal puts headlamp protection on a new level

Hassan KOULOUEH, AML Systems SE

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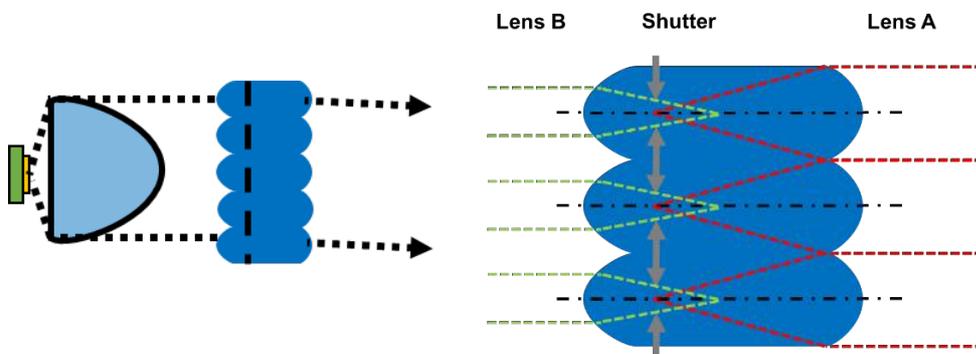
Thin headlamps are the latest styling trend for lighting signatures. During the last two years several concept cars came up with a brand or model appearance.

MLA is already used to form a signature beside the front door of a car. The technology is now possible with front headlights.

MLA is an array of small conventional projector systems. Light from an LED board is collimated on the MLA and able to make the high and low beams.

Huge optic collimates most of the light coming from the LED and appropriate efficiency but thin optics collimates less light and efficiency of thin optic is reduced

The reducing of losses is done by extending of optic in one dimension possible, Reduction of focal distance but efficiency compensation by more LEDs is necessary



MLA consist of 100s to 1000s of channels each illuminating a certain solid angle. The tolerances are reduced by integration of illumination optic, shutter plane and projection optic to one part and Color fringe reduction achieved by superposing of all channels.

MLA is based on *Köhler* illumination. It is a combination of MLAs on two sides in one optical part with intermediate shutter. The optical principle seems a projection system

The first MLA headlamp module prototype shows interesting results.

The main benefits are: Package Space of 20 mm x individual x 30 mm (without heat sink), Lens hight of less than 20 mm, illuminance of 5 lx to 9 lx per LED

The main challenges are: Efficiency of 10% to more than 30 % (depending on mask), internal tolerancing,, and reliability.

Efficiency of first shots shows significant improvement possilbe by freeform of illumination MLA

Conclusion

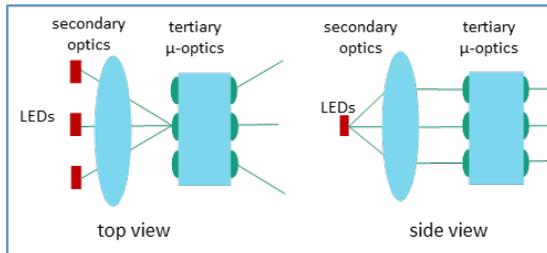
After being a signature beside the front door of a car, MLA is becoming a technology for front headlights to save depth of the optical module.

Micro-optical Headlamp

Peter SCHREIBER, Fraunhofer IOF

Founded in 1992, the Institute for Applied Optics and Precision Engineering, Jena has 265 employees, and 80 students/apprentices for a budget of €29m (43% industry projects).

Micro-optical headlamp allows system miniaturization, design freedom for optical system contours, new light sources with new flux scaling laws, and also new headlamp functionalities (digital lighting).



Micro-optics offers a shrinking system size in all three dimensions, a flexible lateral contouring of optics, a flexible modularization, with comparable high system transmission, and new optical appearance (like diamond).

The System architecture (secondary collimation and tertiary beam shaping micro-optics) fits perfect with LEDs flux scaling by emitting area scaling and the integration of further functionalities like bending light, is possible

First generation segmented high beam demonstrator shows basic functionality, but needs further refinement of collimation optics, improved straylight suppression by housing redesign and micro-optics mastering (work in progress).

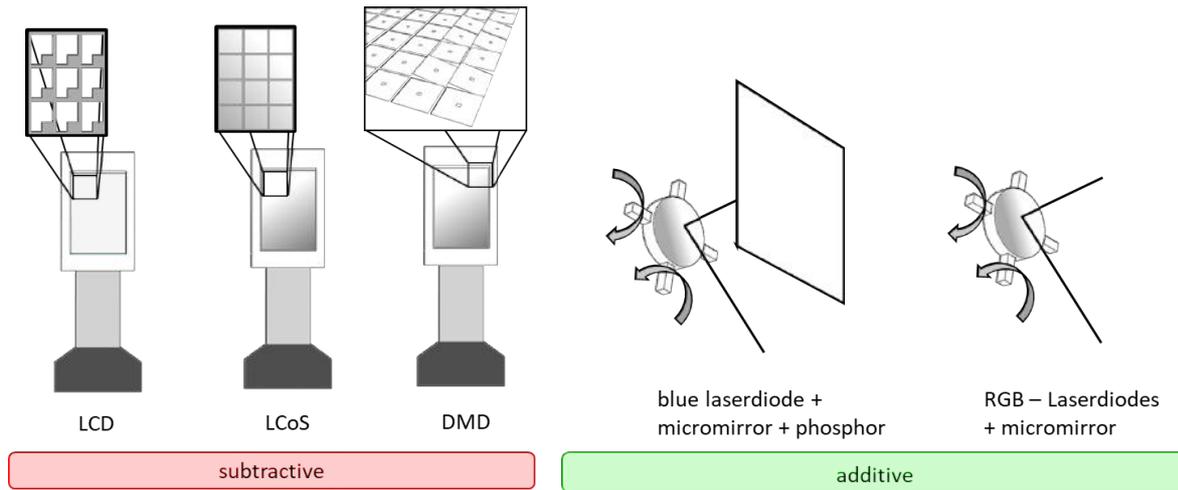
The transmission of high beam can be enhanced remarkably by using rectangular LEDs and/or increase system height, and realization of micro-optics for low beam demo are in progress

Conclusion

Like MLA, the micro-optical headlamp allows system miniaturization, design freedom and new headlamp functionalities (digital lighting).

Technological and physiological analysis of novel projection systems in automotive
Christopher BREMER, BMW

There are many visions of dynamic near field projections in the automobile. On the one hand, there are design-relevant topics: the staging of the Welcome or Goodbye scenarios are an example of this. In addition, there are numerous ways to generate security-related functions.



The turn signal function can be extended by a projection on the road. Functional extensions such as a "door opener" function can also be implemented. Technologies that can dynamically map this content are not yet established. This article summarizes the requirements for near field projections and presents the relevant systems. Technical advantages and disadvantages as well as physical limits are shown. Eye safety limits are also considered. This is a restrictive aspect in particular for RGB scanner systems. In addition to the technological limits, physiological factors such as color perception, flicker frequency or rainbow effects are relevant decision criteria. The influence of polarized light when reflecting on the road is examined more closely and results are presented. Already implemented prototypes are evaluated using these criteria and a technology recommendation is made.

Conclusion

High relevance for future lighting functions in automobiles, since first-time technological consideration for near-field projections in automobiles. Introduction of framework conditions and presentation of new prototypes for the special requirements of the near-field projections.

Illumination vs. Visualization in Headlamps: Way towards HD light source requirements

Stefan GRÖTSCH, OSRAM Opto Semiconductors

Comparison is done between the high pixel count technologies like EVIYOS (active LED Pixel Array), DMD and LCD, considering illumination and visualization.

The imager can be subdivided into subtractive and additive systems. If Spatial Light Modulators (SLM) change the amplitude of the incoming light, they are subtractive systems. In principle, the entire display is illuminated and the content is formed by shading single areas of the display (usually by absorbing the light). Representatives of this technology are LCD as transmissive elements and LCoS as well as the Digital Micromirror Device (DMD) chip as reflective elements. Additive systems are given by the μ AFS technology, and micro-scanner technology. On the illumination side, individual LEDs (white or RGB), phosphor converted laser light as well as RGB laser diodes can be chosen.

The progress towards high resolution headlamps with the possibility to visualize information is on the one hand driving passive modulation concepts towards higher efficiencies or a larger FOV coverage. Here laser diodes might be a solution to come with their increases in efficiency and potentially.

For active pixel arrays the trend to cover visualization asks for smaller pixel pitches and larger arrays which also helps for optical integration. The hetero integrated LED and Silicon Technology of EVIYOS is on the way towards that with combination of attractive efficiencies, moderate complexity and small space requirements

Active condensation removal puts headlamp protection on a new level

Hassan KOULOUEH, AML Systems SE

AML Systems and Gore presented their technology which actively prevents condensation and put headlamps on a new level of protection. AML's Condensation Management Device (CMD) enabled by GORE leverages electrical power and regenerative desiccants to actively remove recurring moisture from automotive headlamps..

Due to the complexity of moisture transfer routes and the broad variety of lamp designs, at present there is no commercially-available "one size fits all" solution that keeps lenses 100% free of condensation. The effectiveness of all existing solutions greatly depends upon the specific ambient conditions and the DP inside the lamp.

Condensation in automotive exterior lamps occurs when the internal lamp dew point is higher than the lens temperature. Condensation is omnipresent and LED technologies, which change the thermodynamic conditions inside the lamps, increase the risk of condensation formation. The Condensation Management Device (CMD) is designed to actively reduce the humidity level inside the headlamp and significantly reduce the risk of condensation. It is an electromechanical device installed on the headlamp housing with one side inside the housing and the other side outside.

Being equipped with a breathable membrane and a radial seal, it allows the headlamp to remain completely sealed and to provide pressure equalization at the same time. No other venting system is needed in addition.

The CMD works as a moisture pump and is operated in cycles. It incorporates a desiccant material that adsorbs the moisture from the inner headlamp and desorbs (releases) it to the external environment when saturated. In the adsorb stage the adsorb gate is opened to the inner headlamp and the desorb gate is closed. The desiccant adsorbs moisture from the inner headlamp, lowering the dew point inside the lamp.

In the desorb stage the adsorb gate is closed and the desorb gate is open to the environment. In parallel, the desiccant is regenerated.

The breathable GORE® Vent on the outside of the CMD reliably allows pressure equalization in each stage and protection from dust and water ingress into the headlamp.

Conclusion

CMD is a clever solution to definitely prevents condensation by actively removing moisture from, and lowering the DP inside, a headlamp.

ADB

Chairman : Laurent Evrard, Valeo

New Systems for Safety and Comfort Improvement by High Resolution Flexibility

Ernst-Olaf ROSENHAHN, Automotive Lighting Reutlingen

Optical Systems for HD Lighting: New Paradigms and New Methods

Pierre ALBOU

Next generation high resolution headlamp in a Jaguar Land Rover with a ZKW development

Gerald BÖHM, ZKW Group

Trends in High Resolution Headlamps

Jeff FARRIS, Texas Instruments

Headlamp DMD-Technology with High Resolution on the Road

Ulrike SCHLÖDER, Automotive Lighting Reutlingen

New Systems for Safety and Comfort Improvement by High Resolution Flexibility

Ernst-Olaf ROSENHAWN, Automotive Lighting Reutlingen

High resolution headlamp systems are key for the next generation of headlamp innovations. About five years ago there were several technologies in research and predevelopment, which had the option to fulfil the requirements of significant higher flexibility for headlamp beam patterns: The beamer technology based on DMD, display technologies like LCD and μ LED matrix arrays and last but not least the ideas around the scanning laser technology. There were two questions: Which one is the first HR technology at the market? Will this one spread to the market best? The first question is answered in the meanwhile with the first DMD system, which started at the market in a series car, but the second question is currently open, because the different technologies open up different steps of improvement. So in this contribution the needs and strategies for integration of high resolution systems into headlamps are discussed.

The target for high resolution headlamps is to increase the resolution in the beam pattern to be more flexible in the field of the well-known AFS lighting functions, to be more performant in high beam as well as in glarefree high beam situations (ADB) and to provide the option to project for driver assistance some objects onto the road surface in front of the car (assistance projection).

The first series car with high resolution headlamps is the Mercedes Maybach presented in March 2018 on the Geneva Motor Show. This headlamp is equipped beside three small modules for the lowbeam base illumination and the 84 pixel module with an additional high resolution module called "High -Digi-Module" (s. figure 1). The mechanical volume of this headlamps allows that arrangement in the headlamp with an additional module for high resolution projection.



Figure 1: World premiere of a high resolution headlamp on Mercedes Maybach (March 2018)



Figure 2: Schematic sketch of the field of illumination for different low beam and high beam components for a high resolution system

In total three different components for low beam and high beam are needed which does not fit the two chamber typical headlamp architecture. There has to be a low beam base to provide foreground and side spread illumination, one component for a conventional matrix for the high beam base illumination and the third part a high resolution system. All of them can be provided by a separate module or as the best solution low beam base and standard matrix high beam base can be integrated in one module. In this configuration the two chambers concept can be kept and the high resolution module integrated to improve low beam, high beam and ADB.

In comparison to DMD HR systems, μ LED matrix light sources are opening the way for less complex HR systems with a slightly lower resolution but a huge potential for a larger number of

cars segments and volumes.

Matrix systems running on the road are equipped with a different number of LEDs and creating segments of about 8 segments up to 84 pixels per headlamp. The different technologies systems open the possibility to adapt their performance primarily to each car segment : for base headlamps even more simple matrix systems and for high performance more expensive HR technologies.

This article provides interesting discussions about size and shape of the field of illumination of HR system, about comparison of HR systems on efficiency aspects and optical systems complexity, and about comparison of high resolution systems to standard matrix solutions in terms of safety, comfort and energy efficiency The integration of high resolution systems into matrix headlamps will give a huge jump in performance increase. The different technologies of high resolution systems will also be able to provide different performance level and lighting function, with costs fitting into each car segment.

Optical Systems for HD Lighting: New Paradigms and New Methods

Pierre ALBOU,

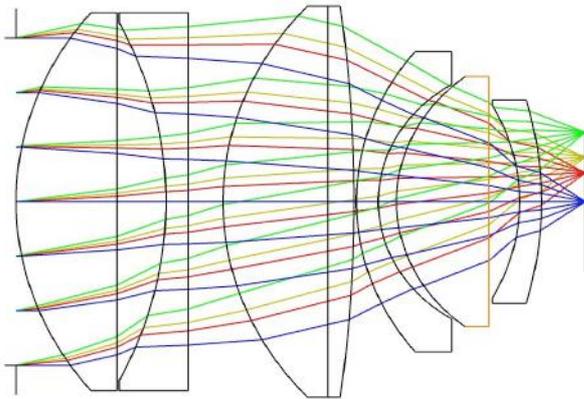
HD lighting requires optical systems of another class than those used in previous automotive lighting: they resemble camera lenses, but also differ from them in terms of specifications.

This paper presents the different sets of specifications from both an automotive lighting and an imaging optics point of view. Typical systems are shown and explained which illustrate this analysis.

The specifications for the new devices are different from those of existing systems and lead to new optical designs. This paper will discuss the specifications according to the targeted function groups and describe examples of resulting optical designs. Displaying pictures is also a current trend and development challenge for rear lighting, where devices of the same kind as those under development for front lighting are investigated.

Due to the near commercial failure of ARS, this constitutes a greater revolution than for front lighting,

where AFS and matrix beam paved the way to PictureBeam. The requirements in terms of luminance are significantly different from those of lighting systems and some solutions are available which would not be suitable, but similarities appear in DMD or pixelated light source based solutions, e.g; the striving for high optical efficiency, poor imaging characteristics, etc. The paper highlights some specifics and similarities in rear lighting applications and show some designs for image / logo projection.



Optical systems for HD lighting : new paradigms and new methods

This paper shows that the new specifications and system structures are significantly different from traditional automotive lighting designs, and also from traditional imaging optical designs. This is part of the new paradigm which affects the OEMs' R&D activities. Another important change has been observed in manufacturing: the tolerance analyses of the systems described in this paper show that they are compatible with usual commercial optical manufacturing. Nonetheless some positioning accuracies must attain $\pm 50\mu\text{m}$ and the precision of several curvature radii are 20 fringes (or $10\lambda \approx 5\mu\text{m}$).

These tolerances are 2 to 20 times stricter than usual clearances in automotive lighting. Acquiring manufacturing processes and design abilities that reach these requirements will take the automotive lighting industry a step further along the path towards high technology.

Next generation high resolution headlamp in a Jaguar Land Rover with a ZKW development

Gerald BÖHM, ZKW Group

Gerald Böhm presented ZKW-JLR joint development for the implementation of another high resolution headlamp concept based on DLP technology as the central element enabling projections on the road while offering a very smooth and comfortable ADB function. It represents a major step towards creating systems that do much more than just generating illumination for the driver.



Figure 1 : Range Rover Sport car with prototype headlamp

To get full legal lighting functions different modules were fitted into the prototype lamp. The DLP Module offers a meaningful field of view in horizontal and vertical and supports dynamic features in low- and highbeam. A Pixel module with 17 segments overlaps the DLP in the center area and gives a highbeam width of +/- 27°. The 9 Foreground lenses give a basebeam of +/-31°. Similar technology is used for the 8 signaling lenses for position light, daytime running light and the animated turn indicator. The static bending light is done with a LED reflector solution.

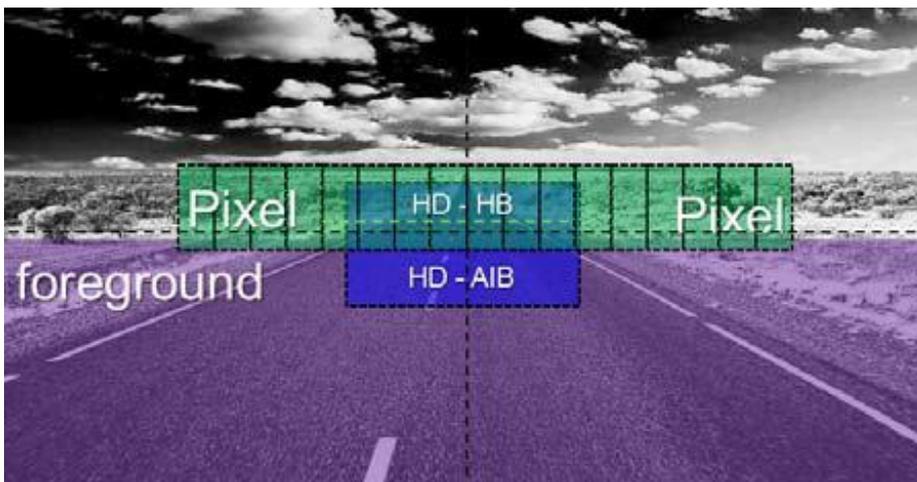


Figure 2 : Prototype light distribution

For ADB the Pixel and the DLP light distributions are overlapped. With the high resolution from the DLP it is possible to project precise tunnels close to oncoming or preceding vehicles. Due to the high vertical resolution the vertical shadow in front of a vehicle, known from common Pixel systems disappears.

A specially adapted Gen2.0 DLP module (2:1 aspect ratio) was being developed concurrently to

offer simplified optics and increased light output. This concept is being developed for series production alongside Jaguar Land Rover and therefore will be used in JLR vehicles for the first time in high volume. The serial camera acts as the main sensor and the lighting and feature control is performed in a separate control unit.

The focus of the project is on analyzing realistic interaction with other light modules in the headlight, coordinating algorithms between camera and headlight control, determining the type and position of possible projected symbols in front of the vehicle depending on the driver's position and viewing angle and much more.

Preliminary results indicate that for ADB, when Pixel and DLP light distribution are combined and overlap, smooth, more subtle light dynamics allowed by HR headlamps stabilize gaze behaviour and possibly visual attention. High-resolution headlight systems can illuminate the road in front of the vehicle by directing targeted light towards critical areas without dazzling other road users, showing all the information the driver needs without forcing them to take their eyes off the road in a critical situation. Auxiliary projected lines and symbols, combined with consciously controlled contrast in the lighting patterns can help drivers in critical situations. These features not only provide high-quality assistance to drivers, but can even act as management tools. Targeted control of the driver's line of sight using dynamic brightness adjustment in light distribution improves situational visibility at night.

Also important are the general improvements in illumination and light distribution that these highresolution headlight systems offer. Cornering lamps, which have been unchanged for years, will essentially remain the same. They retain their analog, continuous character when panning without mechanical moving parts.

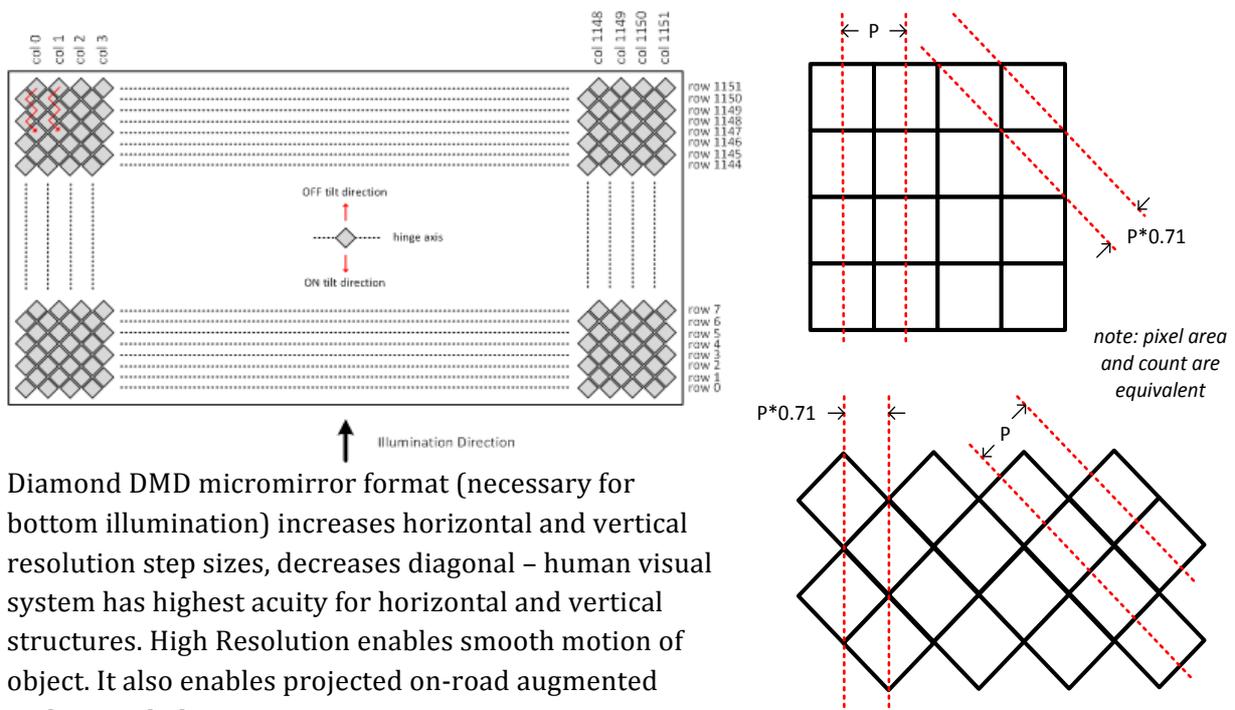
Conclusion :

Once again ZKW, manufacturer of high-resolution lighting systems, has yet another technology in the starting blocks. This new technology will be tested as a near-series prototype vehicle alongside and together with Jaguar Land Rover in order to explore the new possibilities it is offering in practice and to thoroughly understand implications for specification and integration in the vehicle.

Trends in High Resolution Headlamps

Jeff FARRIS, Texas Instruments

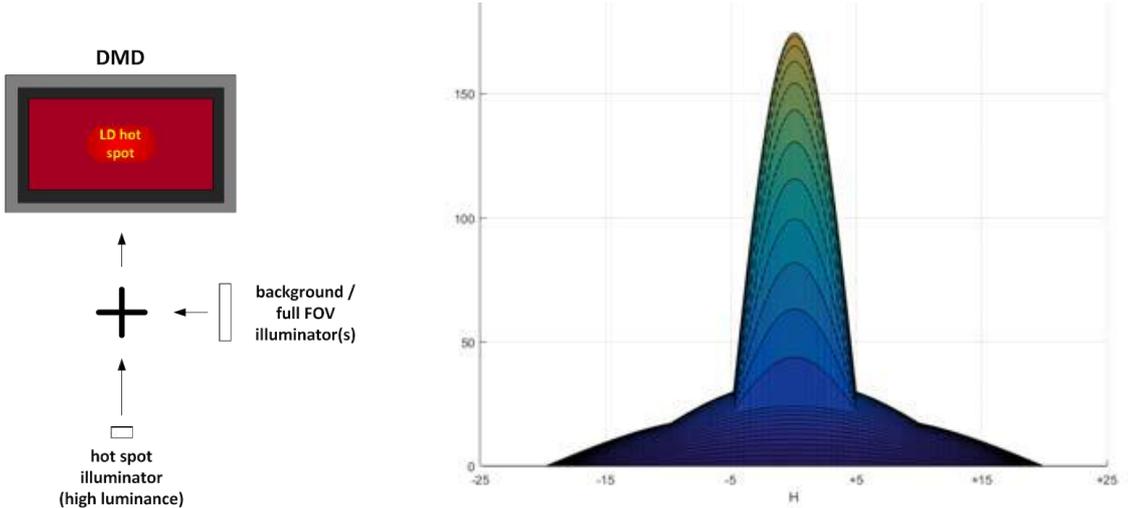
Jeff Farris from TI introduced the new DLP® digital micromirror device optimized for headlamp applications – the DLP® 5531-Q1- 0.55” configured in 1,3 Megapixel Diagonal Micromirror Array with a 2:1 aspect ratio. The heart of this chipset is a 0.55 inch diagonal DMD designed with new advanced headlamp applications in mind. It is 3.19 times larger in active area than the first DMD designed for the automotive market – DLP3030-Q1 and is bottom illuminated. This larger area supports three times greater lumens (for a given illuminator source flux density) and triples achievable peak illuminance while using conventional LED light sources. The high temperature operating range has also been extended to include operation at a die temperature of 105° C. The combination of higher temperature operation and larger imager size helps support a broader headlight FOV than is possible with the previous 0.3 inch diagonal DLP automotive device.



In a second part the presenter illustrated why higher resolution is expanding application and use cases, and outlined some areas of new research. One such application and function would be marking hazardous objects at long ranges. Typically 100 to 150 meter distance range is the distance zone where improving drivers’ reaction would be most beneficial at highway speeds. This is also where the difference between 0.1 and 0.02 degrees per pixel is significant. With only 0.1 degree per pixel of resolution available, only a single on/off line pair can be placed on a 1 meter tall object, whereas a 0.02 degree/pixel system can place nine.

Can high contrast spatial patterns be used to capture the driver’s attention? With sufficient resolution to place patterns on an object, next potential improvement is to create motion within the patterns. Looming and abrupt onset of objects have been shown to capture attention. Can a high resolution headlight create moving/looming patterns (such as swirling lines, moving

arrows on road surface tracking the path to the object) that shorten a driver’s detection and reaction time in situations the driver assistance system has determined are dangerous? These are all areas where further academic and industry research is warranted, now that high resolution headlights are no longer science fiction, but included in real cars on the road. Finally, in a third part, the presenter proposed new laser illumination concepts that could acheive the brightness levels necessary for increasing the FOV size covered by the DMD from the actual reference size of 14°x7° to 30x10 degrees or even 40X10 degrees, thus eliminating the need for a complementary lighting system to complete the etendue of DMD and requiring only a basebeam for the foreground.



Desired illumination profile onto DMD
 The approach developed in the presentation is to supply the on-center hotspot by a single high luminance with small emitting surface white laser module, the remaining task of filling the rest of the DMD etendue being fulfilled by a background LED technology

Conclusion:

Interestingly, this presentation argues that one of the main limitation of the DLP®, its lack of etendue, can find a solution, provided many remaining challenges find a proper solution.

Headlamp DMD-Technology with High Resolution on the Road

Ulrike SCHLÖDER, Automotive Lighting Reutlingen

Ulrike Schlöder presented the Mercedes-Maybach S-Class worldwide first high resolution series headlamps with DMD technology. The new freedom for the creation of light distributions offers not only a significant performance improvement of the existing lighting functions such as AFS-low beam and camera controlled ADB functions, but also opens the opportunity for new lighting functions like guidelines and symbol-projection on the road. This leads to a new level of safety and comfort during night time driving.

In this paper the DMD headlamp module is described, with special emphasis on the DMD chip, the DMD-ECU, the optical concept, the thermal concept, the optical performance and the optical image quality.

The new method of generating light distributions is explained in detail and the improved ADB and AFS low beam as well as the new headlamp projection lighting functions based on the high resolution technology are presented.



Conclusion

For those who had the opportunity to test the Mercedes-Maybach S-Class HR lights during the Vision 2018 night drives at the Mortefontaine tracks, the positive influence of HR technology on ADB and AFS was easy to be noticed. Guidelines projection on the road and speed warning was also demonstrated.

LASER AND HB LED

Chairman : Hitoshi Nakagaki, Nissan

LASER scanning lighting systems – Optimization of contrast and further challenges

Philip STROOP, HELLA

New approaches for laser scanning headlamps

Marcel BURSY, L-LAB, Research institute for automotive lighting and mechatronics

Efficient usage of high current LEDs on ADB systems

Whilk Goncalves, Christopher LE DALL, Groupe PSA

**LASER scanning lighting systems -
Optimization of contrast and further challenges**
Philip STROOP, HELLA

Laser scanning systems are one of the different solutions currently developed for HD headlamps (LCD, DLP, microAFS,..)

There are several advantages for laser scanning:

- Efficient system with an additive light distribution
- High illuminances
- Possible separation of light source and optical systems with use of optical fiber.

In front of that, there are several challenges to overcome:

- Heat dissipation in the phosphor
- Safety
- Contrast

The target of the presented study was mainly to improve the contrast of laser scanning.

This project is done by two partners, Hella and the Fraunhofer Application Center for Inorganic Phosphors in Soest.

It is supported over a time period of three years that started in March 2016 by the ERDF (European Regional Development Fund)

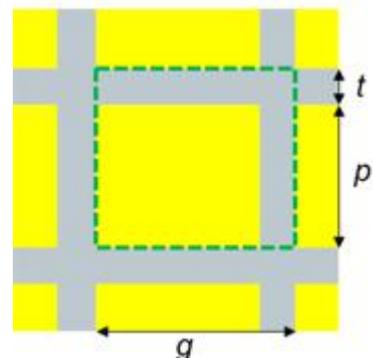
The target is to develop a laser scanning headlamp with the following specifications:

- 2D scan of low beam range and high beam
- 1000 lm on the road out of the scanning system
- Field of view 40° horizontal and 10° vertical
- Resolution of 0.1° by 0.1°
- Frame rate of 200 Hz

The requirement of 0,1° for the resolution means that each pixel on the phosphor need to measure 100 μm for a typical focal length.

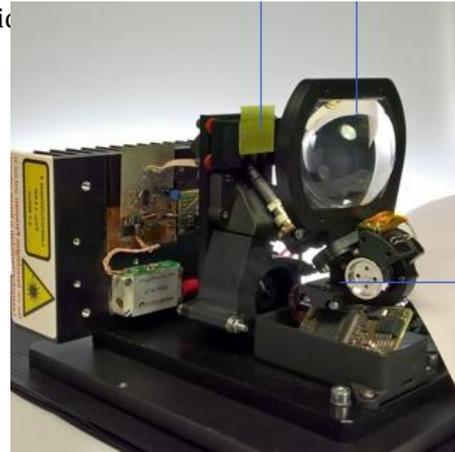
To improve the contrast, trenches were realized on the phosphor, avoiding so the transmission of the light inside the phosphor from an illuminated area to the nearby area.

But to keep a good enough homogeneity, the trenches were limited to 10% of the size of a pixel.



A **prototype was realized** having the following characteristics

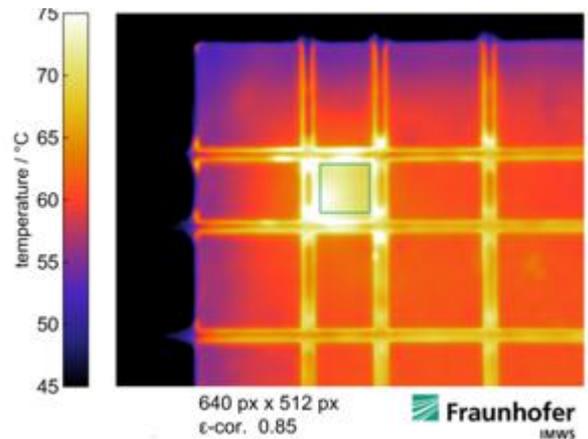
- . FOV horiz. +/- 20°
 vert. +/- 5°
- . Resolution 0,1°
- . Pixelcount 150x100 pix / 8bit
- . Optical power 4,5W (@450nm)
- . Frame rate 133Hz
- . Switching freq. 2 MHz
- . PWM-Pixel freq. > 500 MHz



Results:

. The **heat dissipation is very good** thanks to the reflect approach

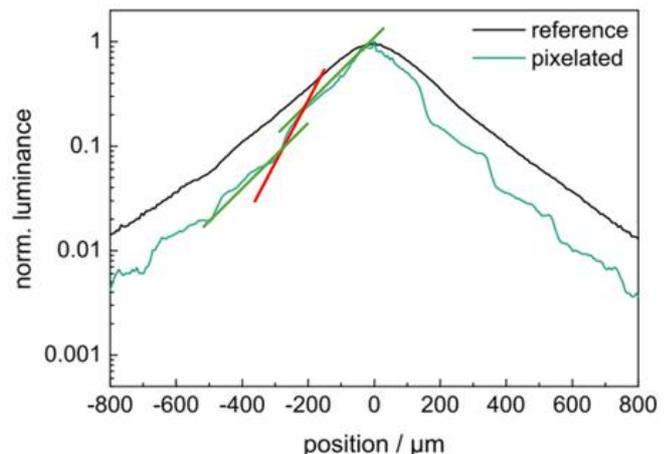
. The **color has to be improved**, this being possible by the adjustment of the thickness and the doping of the phosphor layer.



. **The contrast is improved** compared to a continuous layer of phosphor, but with still a need for improvement.

This is certainly due to the fact that some residual ablated material can be found on the bottom of the trenches as well as piled up material on the edges.

A solution considered for improvement would be to fill the trenches with a non-transparent material.



Conclusion:

Laser scanning systems are considered as one of the most interesting solution for the future of HD systems.

But this project is showing that many challenges have still to be overcome to succeed.

Contrast could be overcome as proposed here by filling the trenches. Other challenges as improved laser power will have also to be overcome.

New approaches for laser scanning headlamps

Marcel BURSRY, L-LAB, Research institute for automotive lighting and mechatronics

Issue with the current deflection systems using MEMS micro-mirrors in laser scanning systems

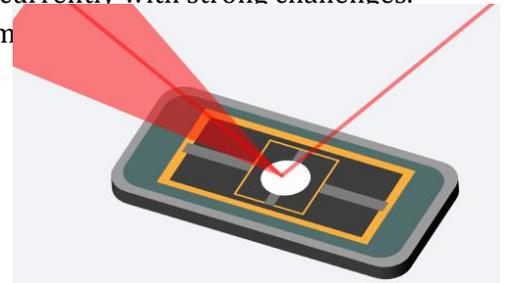
Laser scanning systems have potentially interesting future, but currently with strong challenges.

One of them is the current use of MEMS for the deflection system

MEMS have generally two directions for deflection.

As the movement for the horizontal scanning lines need to be very quick and as there is a minimum of mass for the mobile mirror, it is moved in a resonant mode with a sinusoidal cycle. As a result, the pattern distribution is the contrary of the desired one, with a relatively long time at the extremity of the movement and a short time in the center where photometry is requiring the highest level of light.

MEMS have too limited adjustment and the principle is requiring a high modulation bandwidth for the lasers.



Alternative deflection technologies: Acousto-optics deflectors.

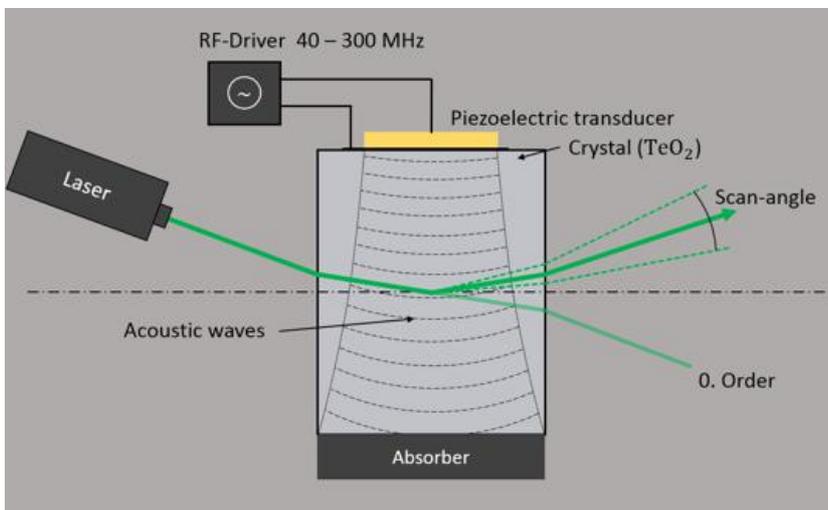
Despite some advantages in relation to robustness and price, MEMs are so not the perfect deflection device for scanning systems. Consequently, an evaluation of acousto-optic reflector was realized.

Principle of acousto-optic deflector:

An acousto-optic deflector is based on the diffraction of a laser beam in a grating formed by acoustic waves inside a crystal. A piezoelectric transducer receiving the driving RF impulses and sending acoustic waves is attached to the crystal.

The rarefaction and compression induced are leading to a periodical change in the material density and consequently of the refractive index acting like an optical grating.

The angle of deflection is so in direct relation to the frequency of the RF driver.

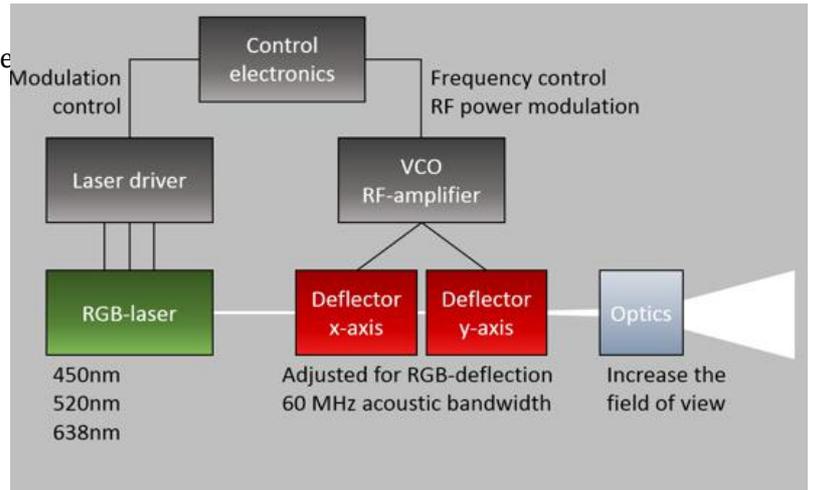


Wavelength range	350 – 1600 nm
Response time	6.5 – 10 μ s
Scan angle	41 mrad \approx 2.3°
Resolvable spots	250 – 400
2D efficiency	> 50 %

Proof of concept:

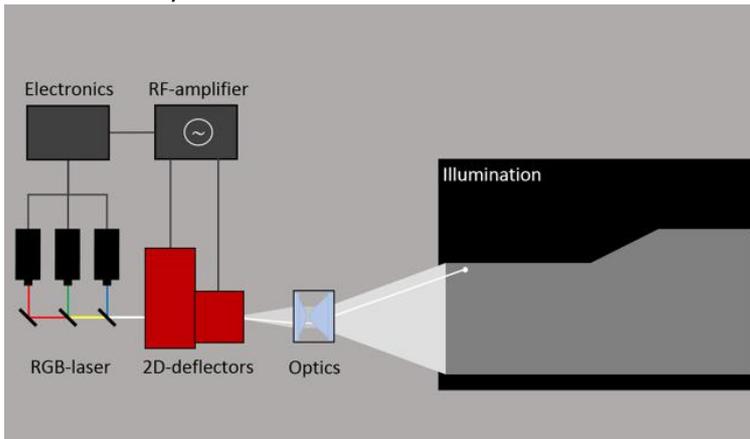
A first experimental investigation is prepared using an acousto-optic deflector. Two possibilities are considered:

- the first one using RGB lasers and dichroic mirrors, with the advantage to optimize the efficiency and with the possibility to obtain any color
- the second one with a blue laser and deflection on a phosphor layer to obtain a white beam.

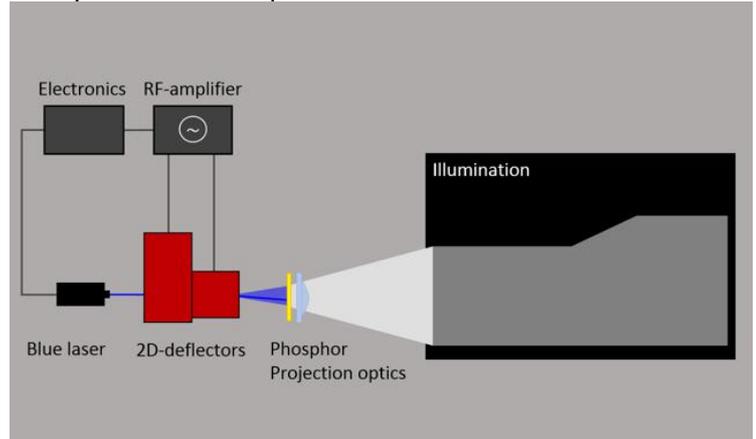


Naturally, this acousto-optic deflector that is particularly interesting for the horizontal fast scanning mode could be coupled with a simple MEMS for the vertical deflection that can be done in a static mode.

System with lasers RGB



System with Phosphor converted illumination



Conclusion:

This development is interesting as it could improve significantly the efficiency of future laser scanning systems currently not optimized due to the limitation of the beam distribution obtained with MEMS micro-mirrors.

Naturally, some challenges have still to be overcome as the amplification of the deflection angle, the frame rate or the electronics control. But the mechanical free, beam pattern free with high dynamics potentially offered by such an acousto-optic system is attractive.

Efficient usage of high current LEDs on ADB systems

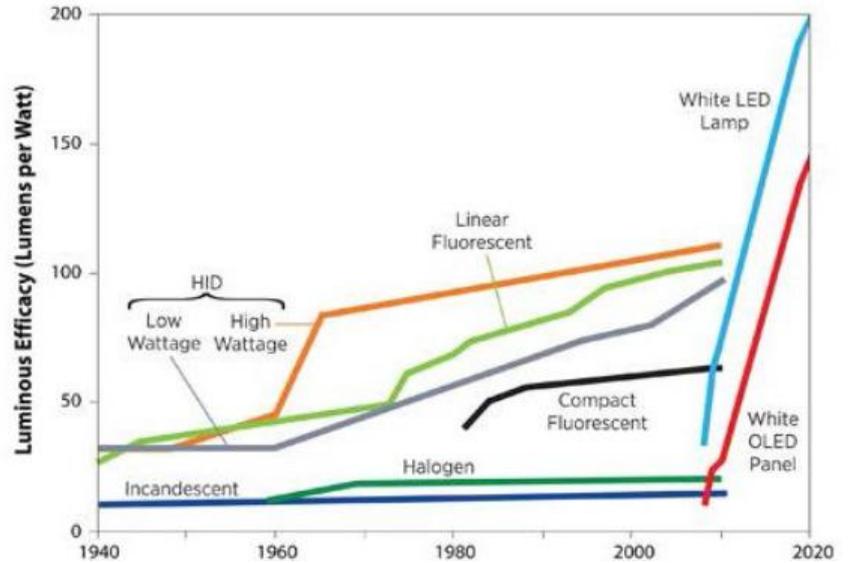
Whilk Gonçalves, Christophe LE DALL, PSA Group

Target: This presentation is demonstrating the interest of the new generation of high current LEDs for some lighting applications

Introduction:

During the past years, LEDs and now OLEDs have increased their performances in lm/W at an extraordinary rate never seen previously with the more traditional sources.

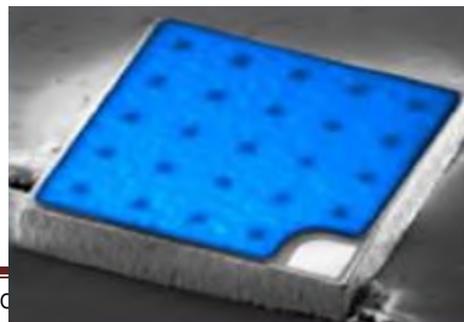
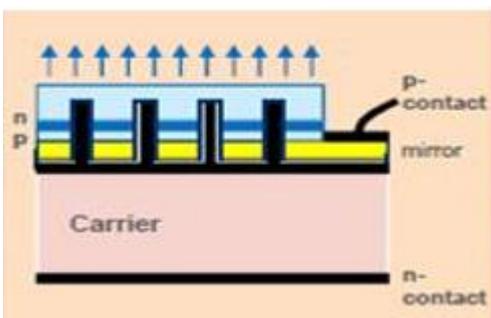
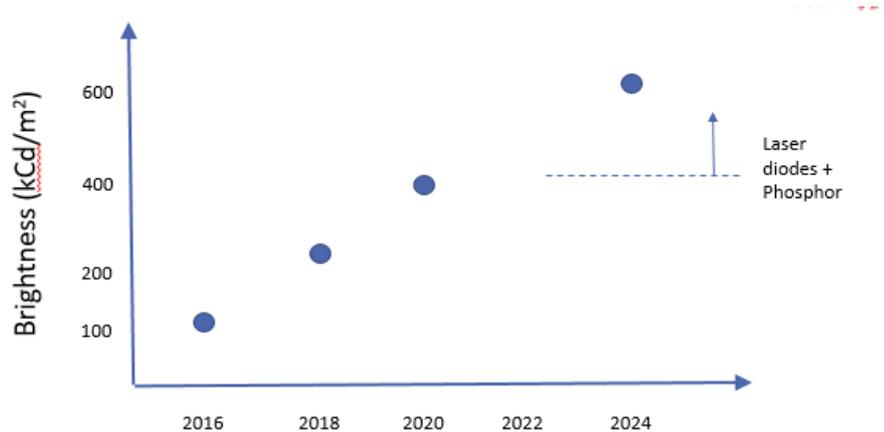
In parallel, to improve the range and so to achieve roughly 500m range, laser sources are now used in still limited applications.



But if laser sources are offering high brightness, higher range and good compactness, they are expensive with a lifetime relatively limited and still with safety features to add.

Characteristics of high current LEDs

Thanks to higher level of current, the luminance of high current LEDs is increasing quickly, reaching today 300 Mcd/m and approaching the level of laser sources with phosphor converter. Currently with a packaging of 1mm and with a current of 3A, these LEDs are accepting such a high current thanks to multiple current injection points



The advantages of these LEDs besides their luminance are a relatively moderate cost compared to laser sources with a much better lifetime. Compared to traditional LEDs, they are however less efficient and with higher heat dissipation.

Integration of HCLEDs

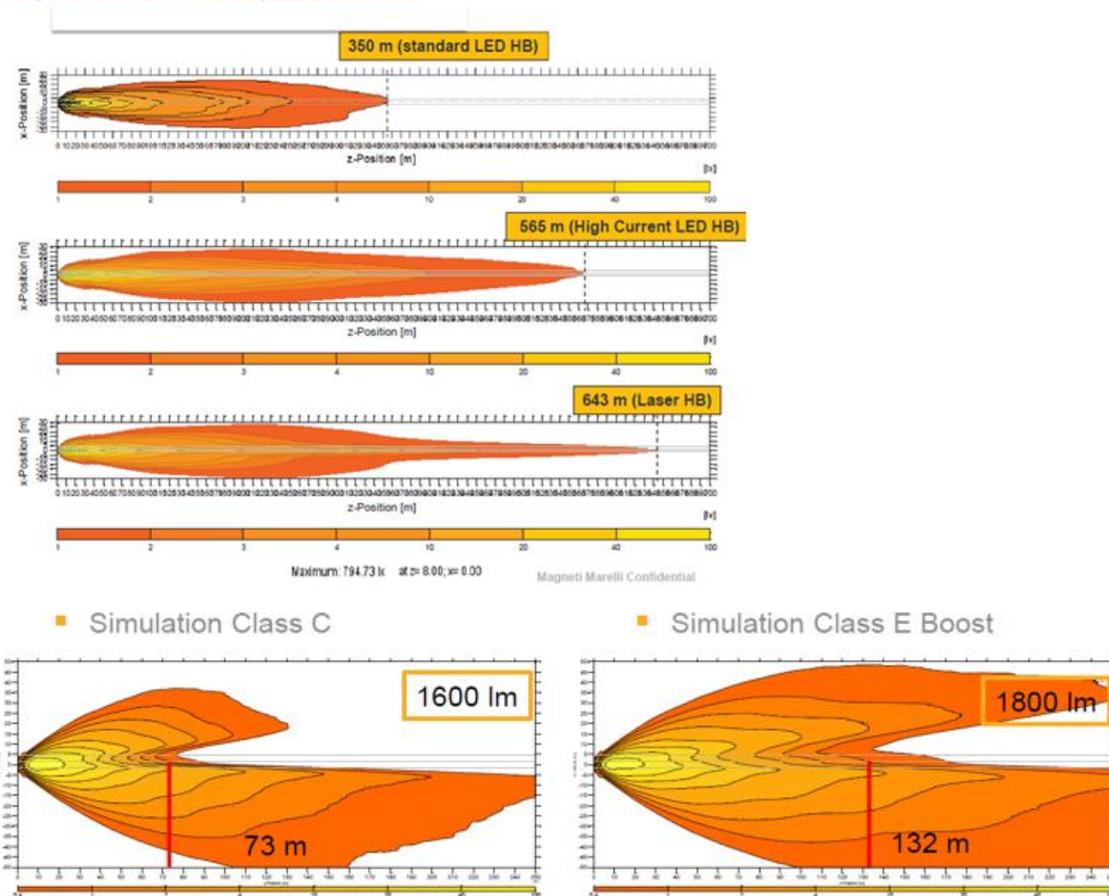
PSA group have done tests in different conditions with Low beam, high beam, bi-function modules, ADB and symbol projection replacing the original traditional LEDs by these HCLEDs. One difficulty was to replace the LEDs on the PCB by HCLEDs with bigger packaging and moreover higher thermal constraint. Simulations were done to optimize and control the heat dissipation.

Results:

With ADB, the bigger images given by HCLEDs are not clearly seen when driving. Naturally, adapted optics would have to be used for an optimized beam.

When used in high beam or in motorway, these HCLEDs are giving a strong improvement compared to normal LEDs approaching the range of a laser version but with a much better width.

High Luminance LED System vs Laser



Conclusion:

HCLEDs have demonstrated in this PSA study their interest particularly for the functions in relation to the range as the high beam or the motorway beams with better range and good width

LIGHTING AND AV

Chairman : Gilles Le Calvez, VEDECOM

Quantitative Safety Evaluation for ADB Systems Using a Virtual Traffic Simulator

Tatsuma KITAZAWA, Koito Manufacturing

Advanced lighting functions with high-resolution road projection

Basile KHATIR, IOGS - ELS Chair

Automated vehicle lighting - Opportunities in regulations to further safety on the road

Helmut TIESLER-WITTIG, LUMILEDS

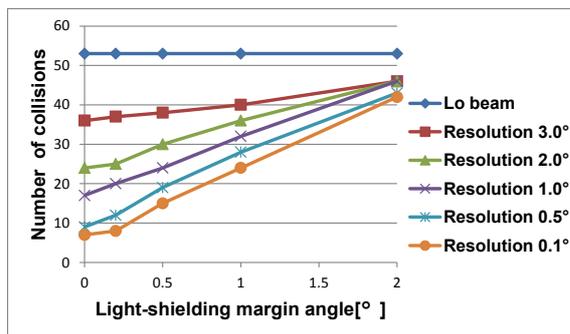
Quantitative Safety Evaluation for ADB Systems Using a Virtual Traffic Simulator

Tatsuma KITAZAWA, Koito Manufacturing

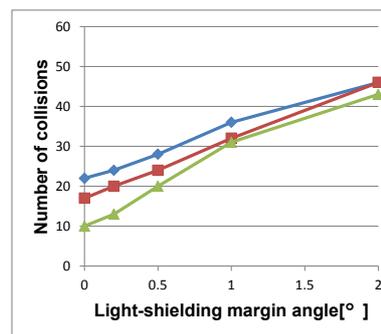
In this study, the author evaluates in simulation the interest of ADB in function of different parameters: Type of Technology used, Resolution, Margin angle, Blur width and luminous intensity.

The correlation between the system's irradiation performance and accident reduction effect has been studied. The number of occurrences of traffic collisions with crossing pedestrians was obtained in the simulations of human driving of the vehicles equipped with ADB systems by replicating traffic environments in virtual spaces on personal computers

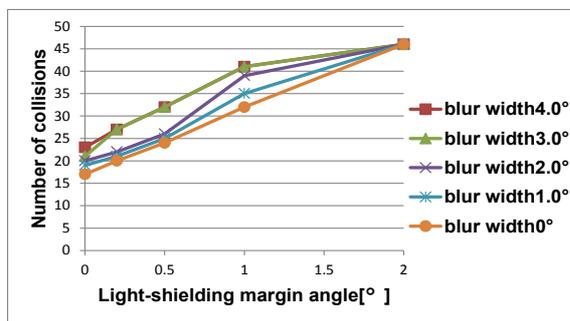
Results:



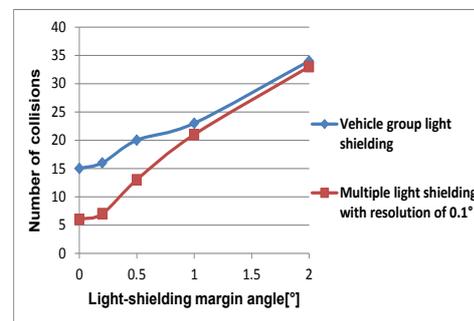
Margin angle and Resolution



Effects of Luminosity



Effects of Blur width



Irradiating the area between vehicles

Although under limited conditions, the results confirmed that the light-shielding margin angle or resolution tend to have a significant impact on the number of collisions, while the impact of luminous intensity or blur width tends to be relatively small. The study conducted also in function of pedestrian walking speed demonstrates the reduction of collision at higher walking speed.

Under these simulation conditions, the number of collisions decreased in all types of ADB compared to when using Low Beams and therefore the usefulness of ADB was confirmed.

Conclusion

This study once again demonstrates the high interest of spreading ADB technology in a wide range of cars to reduce the number of fatalities on the roads. While conducted in virtual reality under limited conditions, the results should be verified in the actual traffic environment.

Advanced lighting functions with high-resolution road projection

Basile KHATIR, IOGS - ELS Chair

This paper presents a research work conducted at ELS chair in collaboration with Karlsruhe Institute of Technology and supported by GTB to provide further knowledge on new lighting functions using road projections, which are still under discussion in the automotive lighting community. Part of the work also studies the shape of the road projections to further enhance awareness regarding the intended movement.

Case study has been departing of a car in a parking lot. Assessments were done either with display on a screen or projected on a parking.

Several shapes have been designed including: Color, animation, Indication of direction, pattern or simple shapes, with arrow or circular shapes



Significant preference has been demonstrated for animated shapes with indication of moving direction and for patterned shapes and with arrow types.

In order to assess the impact of the road projection on road users, and the communication effect: will they understand that the car is departing and how will they act? And do we perceive any safety benefit? A test has been defined with 30 test subjects and 3 types of participants: drivers, cyclists and pedestrians, naïve or already informed participants. The tests will be conducted soon with objective OBD driving data (acceleration, deceleration, brake pedal pressure, steering angle..), interview after the tests and subjective assessment done using questionnaires.

Conclusion

This type of study conducted by University collaborations is key to establish new standards to communicate in the environment of autonomous cars.

Automated vehicle lighting - opportunities in regulations to further safety on the road

Helmut TIESLER-WITTIG, LUMILEDS

Automated Driving (AD) will fundamentally change the overall human mobility and usage of cars. For several decades we will see mixed traffic between automated vehicles and “normal” vehicles as we can see on the chart below

For the safety of traffic, all road users to be taken into account!

Although the new produced vehicles will reach a high adoption rate, it takes a while until traffic changes!

- The car park changes with a different speed
- As a consequence, we have to accept that MIXED TRAFFIC is the usual condition



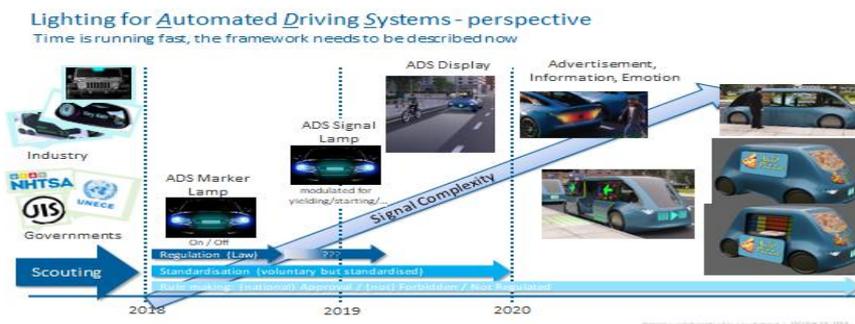
The safe and non-disruptive integration of automotive vehicles into “normal” traffic will ask for a new way of communication between the vehicles and their environment.

There is a need for future Lighting with automated vehicles, going from a function **to see** in headlighting today to a function **to see and sense** in the future and from a function **to be seen** in signaling **to be seen and communicate**.

Visualize the status of the autonomous vehicle is key for other traffic participants. Lighting can do this, but standardized, unambiguous and international language is needed.

To the expert’s opinion, Lighting appears as good technology to generate intuitive, easy, fast and language independent communication

But time is running fast as described in the chart below and the regulation scope needs to be defined quickly as more wide communication we will want to do, more the complexity will be!



The Introduction of further automation in road transportation will lead to an increased demand for reliable communication between road users. The introduction of a dedicated ADS signal to indicate the ADS status and further ADS signals to communicate with other road users seem to be a good option for road safety improvements.

Conclusion

Huge opportunity for Lighting, but standardized signals needs to be defined very fast in order to follow the aggressive Autonomous Driving Cars development.

VISION SYSTEMS

Chairman : Matthieu Dabek, PSA

Camera Based Lost Cargo Detection for Automated Driving

Thomas FECHNER, Continental Corporation

Deep Multi Task Learning based Object Detection and Semantic Segmentation Network for Autonomous Driving applications

Ganesh SISTU, Valeo

Far-Infrared thermal camera: an effortless solution to improve ADAS detection robustness

Emmanuel BERCIER, ULIS

Major steps towards vision processing for automated vehicles

Olivier SBANSKI, Robert Bosch

Camera Based Lost Cargo Detection for Automated Driving

Thomas FECHNER, Continental Corporation

Target:

Different objects can be lost by cars or trucks on roads or motorways and so being dangerous. Their detection in automated driving mode is absolutely necessary. The presentation from Continental is showing how their detection can be done with cameras.

Difficulties of cargo detection:

A large variety of objects can be found on roads. They are difficult to see at far distances and can be confused with part of the road or the sides of the road.



Sensors that can be considered for cargo detection

Radars, Lidar and cameras are the main sensors used for autonomous cars with the following abilities:

	Radar	Lidar	Camera
Resolution	1°	0,1°	0,01°
Range	up to 100m	up to 100m	up to 100m
Height measurement	no precise	limited	precise

Radar and Lidar have not currently the required resolution for a good enough recognition of such objects.

Which camera for cargo detection.

As the objects could be small and their detection difficult at long distance, a telephoto camera is giving a better resolution:

Wide 40 pix/°

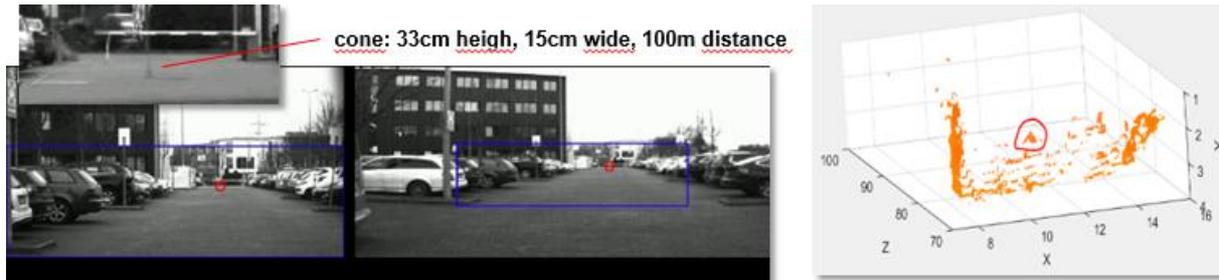


Tele 80 pix/°



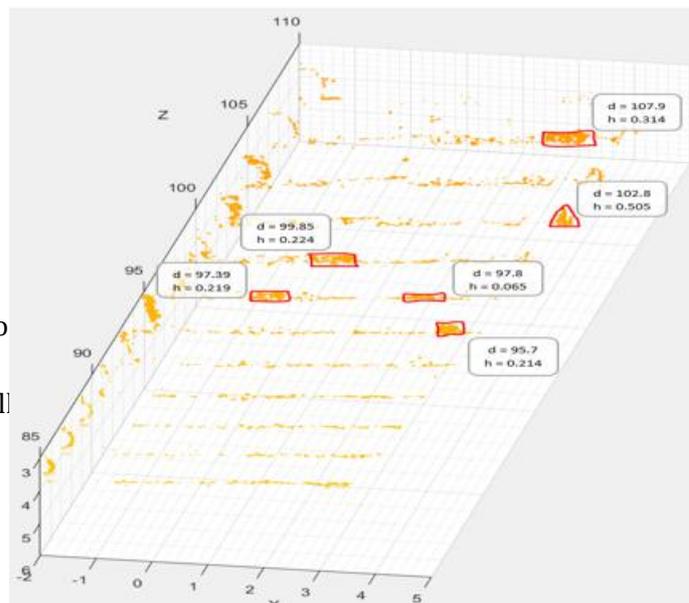
With such a CNN (Convolutional Neural Network) telephoto camera, small objects with a height of 15cm can be detected at 80m. However, false detections could occur requiring a complementary information.

Continental has also tested a system using their multipurpose cameras (for rear-vision or side vision) called satellites, two of them being attached to the windshield with two different focal distances, one for telephoto and one with a larger field of view. These cameras were working according to the stereovision principle by using the difference of angle of view of the object from the two camera, this giving an estimation of the distance of the object.



The combination of the two images is giving a map with distances and approximate height and shape of the detected objects.

High resolution satellite cameras with a field of view of 30° and with a resolution of 140 pixels/° were also analyzed. These high resolution cameras are giving both the resolution normally given by a telephoto camera and the field of view of normal camera. The 3D depth map obtained is relatively good with a distance between the two cameras of 50cm. With this system, detection of small obstacles with determination of their height is possible



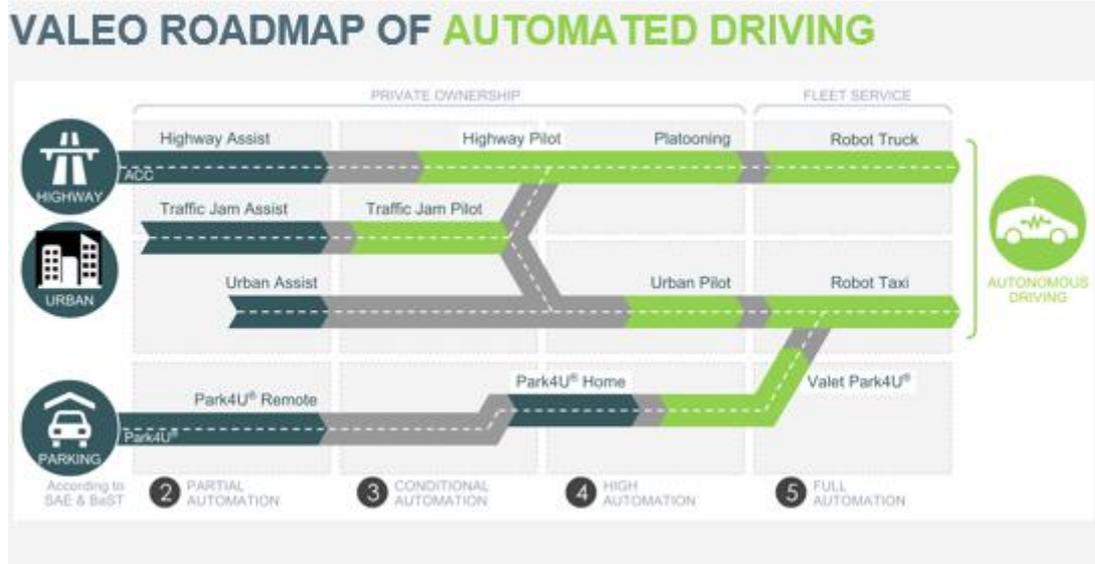
Conclusion

The most reliable solution is to use a CNN based lost cargo telephoto camera in combination with high resolution satellite stereovision system.

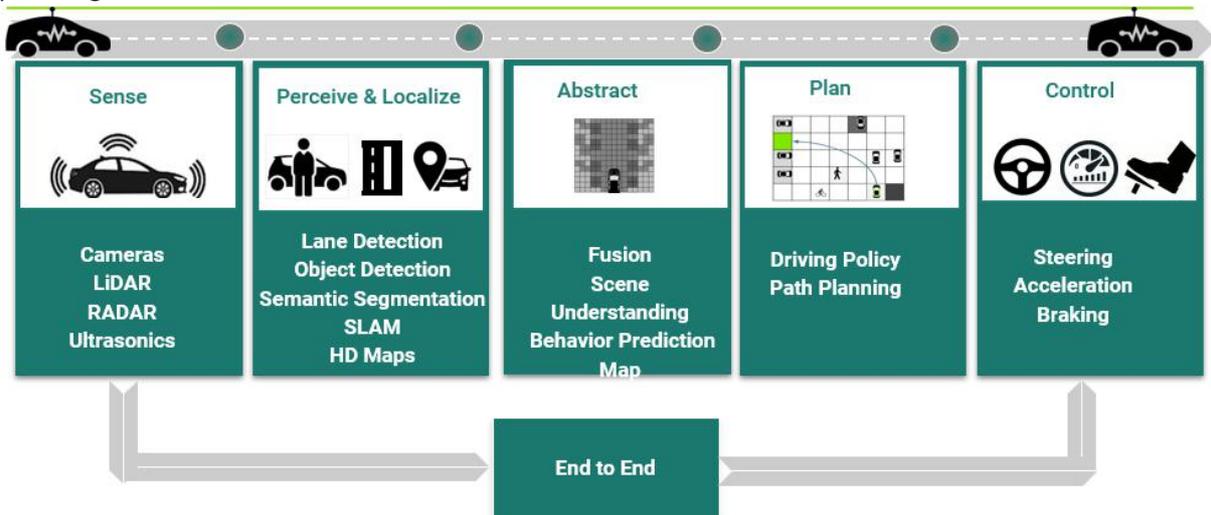
This demonstration is illustrating the fact that with the current techniques, several devices here several cameras are needed associated with CNN to provide a good enough information for autonomous driving.

**Deep Multi Task Learning based Object Detection
and Semantic Segmentation Network for
Autonomous Driving applications**
Isabelle LEANG, Ganesh SISTU, Senthil YOGAMANI

Valeo is developing Autonomous driving in many directions with the following roadmap:



The way to Autonomous driving is complex from sensing systems to the final control through the perception and localization of the road and the objects, the abstract of the scene with the understanding of the situation, then the elaboration of the plan with the driving policy and the path planning.



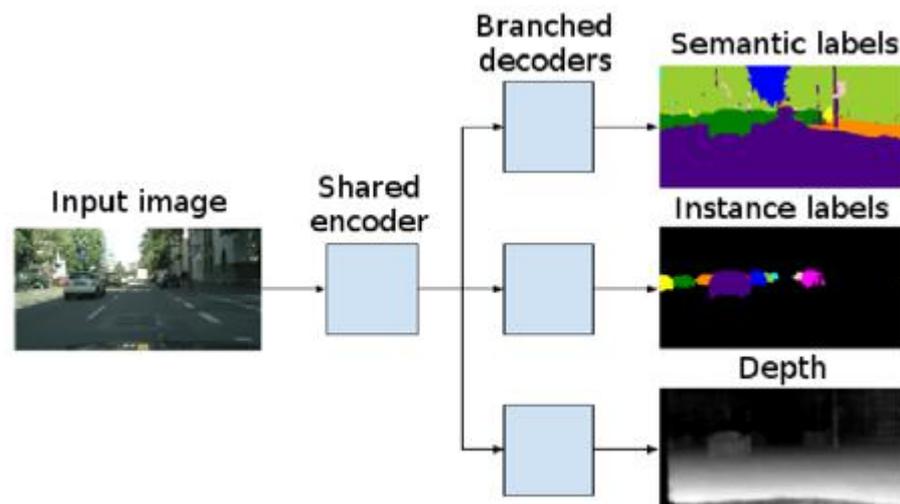
A good visual perception is essential with its different facets: Detection and Segmentation of users and environment, Motion estimation of other users, 3D reconstruction and determination of the drivable area.

For this Visual perception, Deep Learning is the lone way to be able to take into account the huge variety of situations, Deep Learning being the art of building machine learning algorithms that can outsmart their human counterparts from simple to some most complex tasks. This system is based on CNN principles (Convolutional Neural Network) which is learning features versus hand crafted features with genericity of low level features.

For automated Driving, it is essential to identify roadway objects as lanes, curbs sidewalks and poles as well as dynamic objects as pedestrians, vehicles and cyclists. An accurate segmentation of the roadway entities and the detection of the dynamic entities is the base for a good scene understanding.

For each information, a complex multitask analysis has to be done where Deep Multi Task Learning (DMTL) can give some advantages. DMTL is meaning that multiple learning tasks are solved at the same time while exploiting commonalities and differences across tasks.

Example of architecture of DMTL:



A DMTL multitask network with two simultaneous tasks, three segmentation classes (background, road, sidewalk) and object classes (car, person, cyclist) has been developed by Valeo and compared to the use of two single task network, one for detection and one for segmentation with 4,9 million parameters

Results:

Performances were similar both for segmentation and detection.

But the DMTL is giving significant advantages for memory use and computational efficiency.

Conclusion:

Autonomous driving is requiring to take into account infinite number of situations and objects where Deep Learning systems (Convolutional Neural Networks) are essentials. Their efficiency and so the reaction time with similar hardware can be improved with multi-tasks DMTL architecture

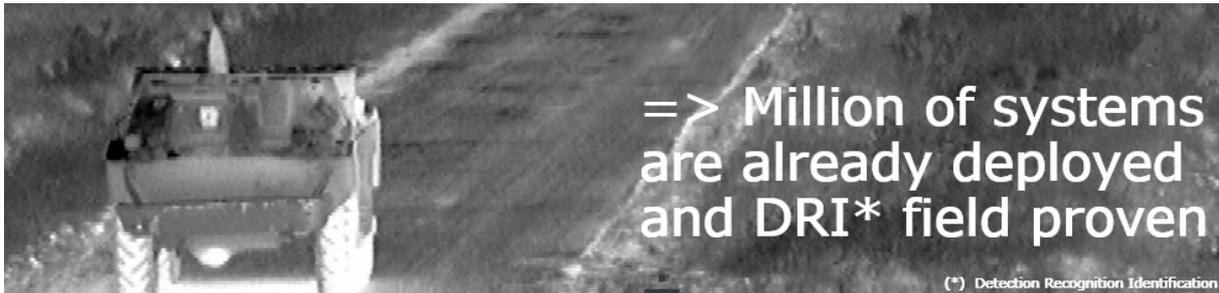
Far-Infrared thermal camera: an effortless solution to improve ADAS detection robustness

Emmanuel BERCIER, ULIS

Road fatalities are still high despite some progress, but results are worsening for pedestrians and cyclists. For instance in France from 2010 to 2016, there was an increase of deaths of 15% for pedestrians and 10% for cyclists.

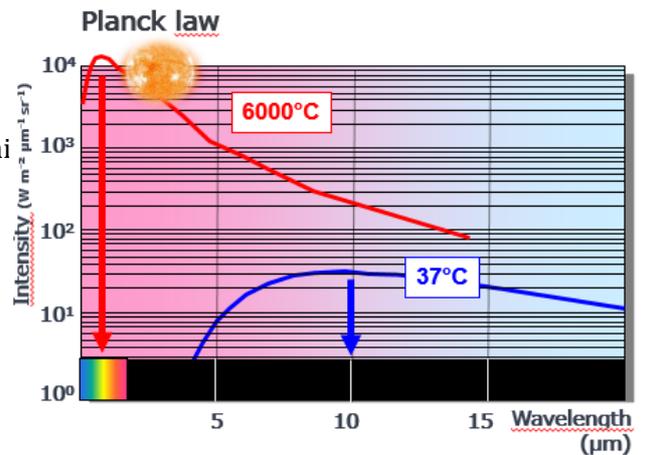
It is recognized that AEB (Autonomous Emergency Braking) is able to reduce road fatalities by 13% to 18%.

The most difficult situations for detection are in bad weather conditions. For such conditions, armies are using since many years thermal cameras.

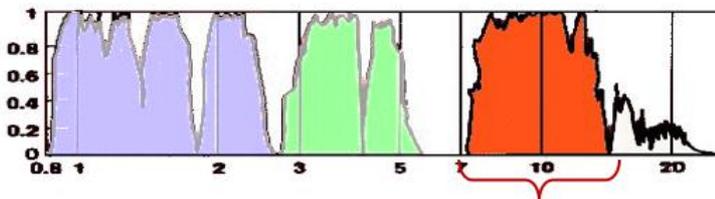


These cameras are using the properties of emission of animals and particularly humans having a peak of emission intensity at $10\mu\text{m}$, so in the far infrared domain

A complementary interest is that the corresponding wave length has a good atmospheric transmission, do not depend to any light condition, is immune to any glare and is also visible in fog condition.

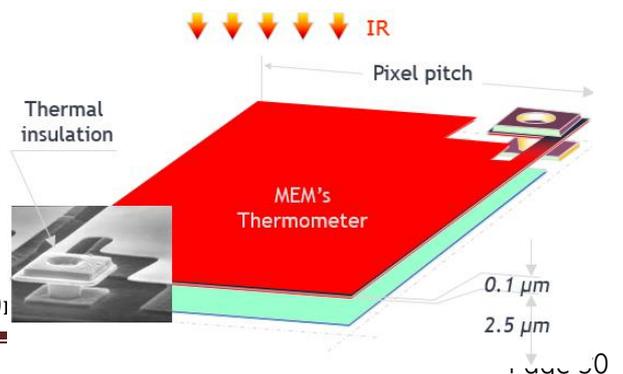


Atmospheric transmission



Pedestrian emission pic:
 $\lambda = 10\mu\text{m}$

Ulis has developed a bolometer for IR acquisition up to XGA definition with 120fps and with a thermal sensitivity of 0.05°C with shutterless and realtime calibration.



This system is allowing pedestrian classification till 100m

Ulis has done parallel tests with a visible RGB camera of 2 M pixels and with a thermal camera of 320x240 pixels count, 12µm pixel pitch, 30Hz, <1W, and with a spectral bandwidth of 8-14µm.

In rural conditions, a pedestrian is detected with the thermal camera 5s earlier (We can suppose that the cameras were fixed, the pedestrian approaching to the camera at a normal speed of 5 km/h, so with a detection 7m better with a thermal camera than with a visible RGB camera)

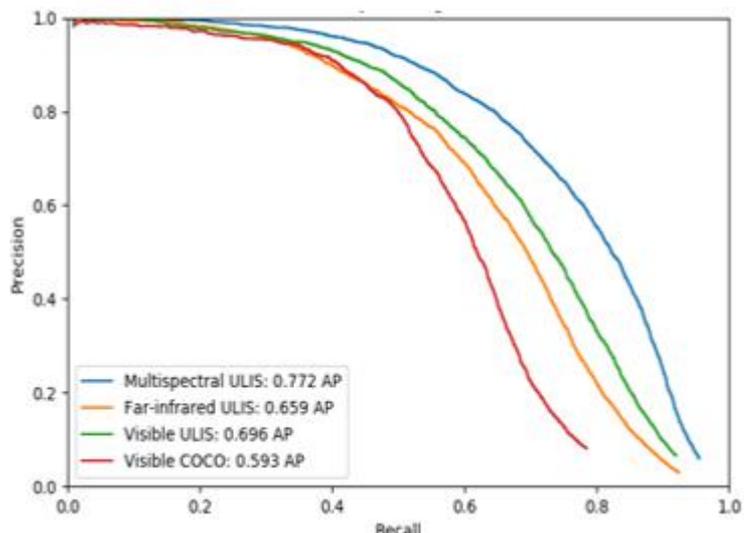
In town, the thermal camera is sustaining the classification given by the camera with a probability of classification of 88% instead 80% for the RGB camera.



The thermal camera is also giving better results in glare conditions or when pedestrians are in dark areas in bright environment.

With a multispectral system using both a RGB camera and a thermal camera, thanks to a basic fusion, the classification was already improved by 11%.

A deeper work with a smart design CNN for sensor fusion would certainly improve again this benefit



Conclusion:

Thermal cameras were used since a long time in vision systems, but with limited applications as the interpretation of their results by humans are difficult.

But for autonomous driving, they are for sure improving significantly the detection and classification of pedestrians more particularly without the possibility however to replace totally normal cameras.

Their large diffusion will depends on the evolution of their cost still currently higher than normal cameras.

Major steps towards vision processing for automated vehicles

Dr Oliver SBANSKI, Robert Bosch GMBH

Introduction:

High Automated Driving (HAD) is corresponding to levels 3 to level 5 of the SAE classification. HAD will improve significantly the traffic flow potentially till 80%, will give productive time to drivers, will give access to mobility to elderly or minors people, and will certainly reduce the number of accidents that are mainly caused by human errors.

But the journey to HAD is long as vehicles need to know at any time in any condition what is happening in order to be able to define a proper and safe behavior.

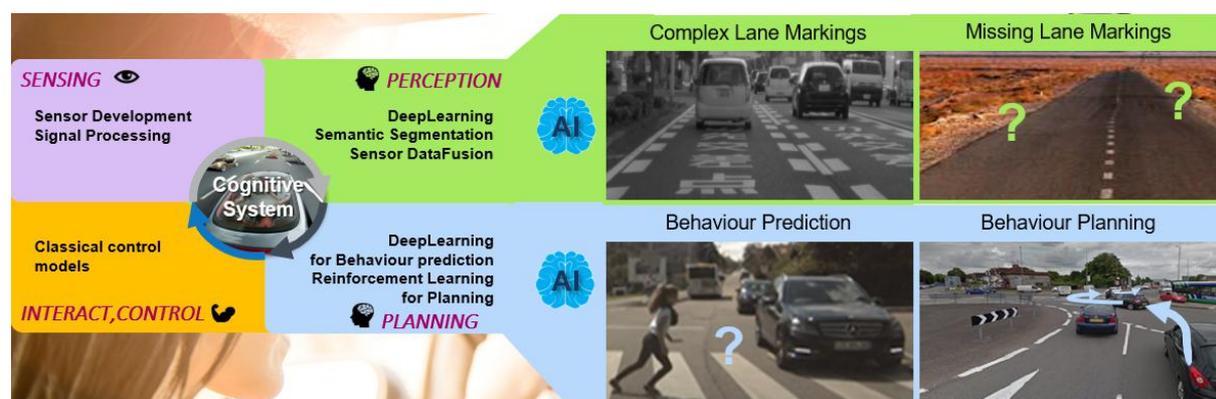
The system needs to be both safe and intelligent, and high standards are necessary to monitor and react instantaneously to constant changing and complex environmental conditions.

Bosch approach to deal with these challenges is an embedded Deep Learning system and a so-called Multi-path approach for parallel paths for the evaluation of the scene.

Thanks to a pixel-wise semantic segmentation, 3D measurements with a stereovision camera, and specific algorithms, the Multi-path system is allowing to create redundancies for a double checking of the input of each path.

Realizing an Embedded Deep Learning System

A way to have automated driving is to copy the human cognitive system with the traditional cycle Sense-Think-Plan-Act.

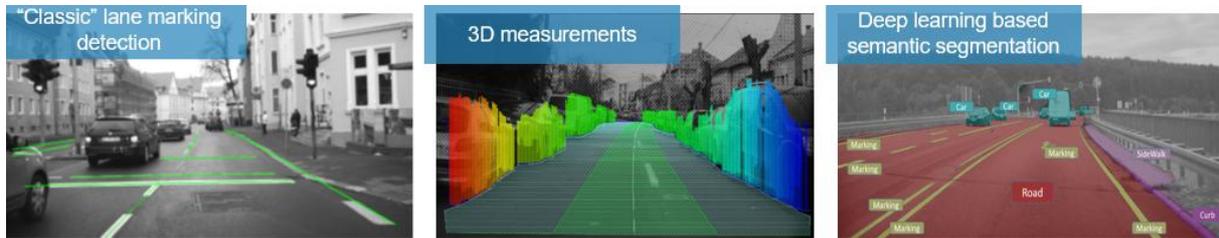


Deep neural network and classical approaches: Classical approaches analyze only one or few features to extract from an image. These features chosen by experts in their algorithms, for instance contrast for lane detection, have limits in complex situations. In these cases, deep neural networks are outperforming classical approaches as their features bases are learned during training with the use of the entire context information similarly as human eyes.

Semantic Segmentation: This method do a classification of each pixel of each image for the detection of the driving space. This is realized with a deep convolutional neural network (DCNN) with adjustable numbers and types of classes.

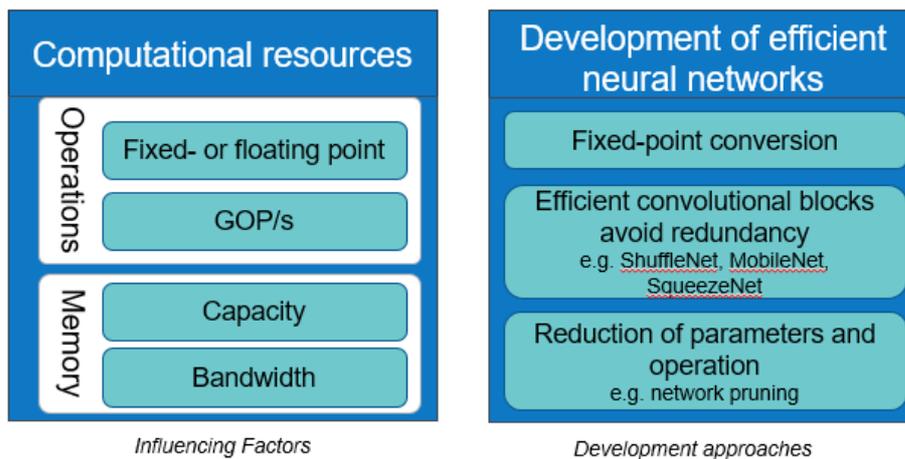
Recurrent Neural Network: In complement to the previous approach exploiting the spatial context, it is also necessary to have a behavior prediction of other users. This is obtained by the analysis of time-series images in Recurrent Neural Networks (RNN) using Long Short Term Memory ((LSTM).

Big Data and Labelling: The key of success of this method is to have a high amount of labelled data. The main difficulty is to label the data, operation that cannot be done manually, with big DNN (Deep Neural Networks) building graphs showing the interconnection of elements in the scene.



Multi-path system: To provide a reliable and robust understanding, several algorithms using several paths (available driving space, segmentation) are combined. In parallel, 3D measurements from a stereovision camera are used in a complementary path.

Deep Learning going Embedded: Applying Deep Learning in automotive is a challenge as hardware resources are limited. Energy consumption is also important and Bosch has a solution with an energy consumption less than 5W where the Nvidia GTX Titan is consuming 250W. The main questions for the definition and the optimization of the hardware are the following:



Bosch decided to use a 8 bit fixed-point arithmetic system. This architecture is much more efficient for power consumption, memory size and speed. To succeed in precision with this architecture, Bosch needed to carefully select the best fitting fixed-point for each layer. In parallel, Bosch has reduced drastically the number of convolutions using already known building blocks.

Results: Finally, with a number of operations divided by 50, the accuracy of the Boschnet system was similar to the reference model (VGG16)

Conclusion

Bosch demonstrated the need of Deep Learning, multi-path, data labelled acquisitions for high Automated Driving, and presented an optimized solution for the corresponding hardware. He opened also the door to some research directions as the more intensive use of deep learning to replace the current probabilistic current fusion of algorithms and sensors. This kind of research is certainly the key to have in the future very reliable Automatic Driving.

OTHER TECHNOLOGIES & SIMULATION

Addition of perturbances on ideal values of a target

Stéphanie AMBROISE, Renault

Simulation of Detection Performance by LiDAR Location in Automated Vehicles

Hiroto IKADAI, Koito Manufacturing

A breakthrough in Automotive Radar with Infineon Radar Signal Processing Unit

André ROGER, Infineon Technologies

Ensure Sensors Vision, a Challenge for Vehicles Automatization Safety

Frédéric GIRAUD, Valeo Wipers Systems

3D mapping and localisation using high-resolution radar and lidar

Johan DEGERMAN, Saferadar research

Addition of perturbances on ideal values of a target

Stéphanie AMBROISE, Renault

Autonomous driving will need to increase the number of systems based on sensors like cameras, radars, lidars and so on.. To validate these systems safety, experts estimate the numbers of kilometers to drive about several

hundreds of millions, may be more than a billion. Real world testing would be dispendious: it would take

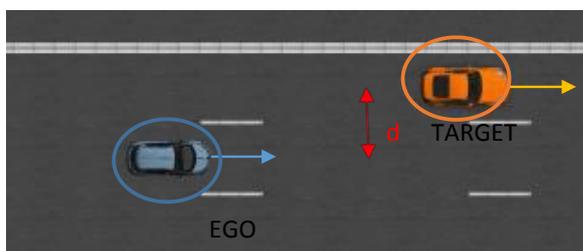
years and years for thousands people to run all these tests. Moreover, some of these tests are dangerous

to be run in real conditions. This is why validating thanks to simulation is necessary.

Redundancy of sensors and their fusion to improve the reliability of a system is a must. The task of fusion is to localise the ego vehicle in the real world, considering errors of these sensors.

Simulation needs models. The first part of this paper presents the architecture of the ideal smart sensor model. The second part deals with the different types of tests and the different scenarii leaded to obtain data noise model. The third part is about the validation of the ideal smart sensor model enhanced with the noise model.

Having described the integration of on ideal smart sensor into SCANeR studio, the simulation tool used in the Renault-Nissan Alliance, the presentation then explains how to build a relevant model of perturbances for positions and speed of a target detected by a radar or a camera



Tests and scenario to obtain data perturbances

An ego vehicle is equipped with the sensors to be characterized and with a ground truth sensor. Different scenarii are run and during each scenario, measured values (in blue) and ground truth values (in red) synchronized with time are stored.

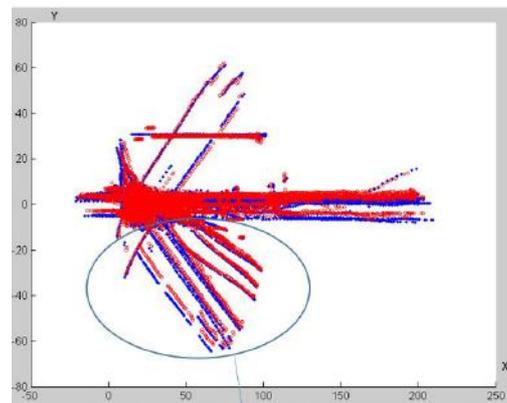


Figure 8: display of ground truth values vs measured values

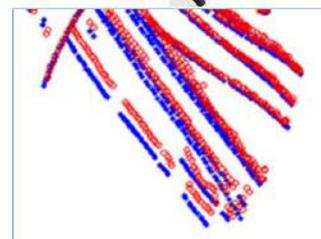


Figure 9: zoom of a part of the figure 8

Conclusion :

This is a tedious and huge project requiring enormous amounts of data, hence the call for sharing the task with other players.

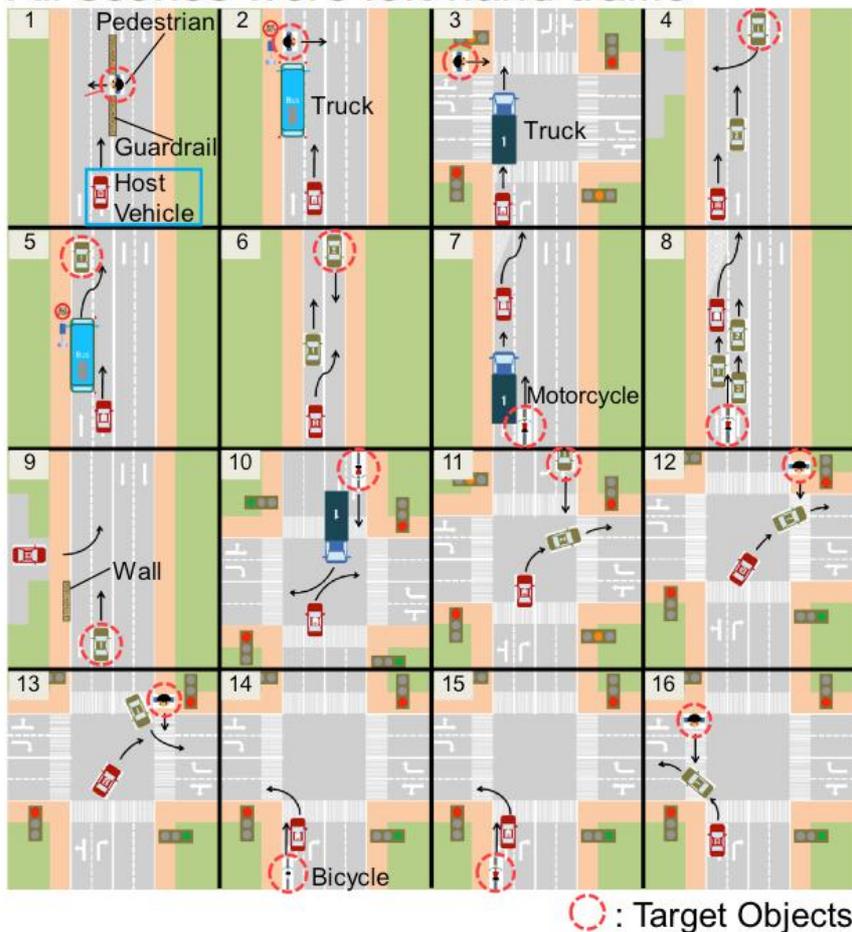
Simulation of Detection Performance by LiDAR Location in Automated Vehicles

Hiroto IKADAI, Koito Manufacturing

While possible locations for installing LiDAR include the roof, bumper, front grille, and headlamps, Koito paper proposes to integrate LiDAR into the headlamps and rear combination lamps. Since the LiDAR's height above the ground and its line of sight depend on the installation location, the performance in detecting the surroundings will likely vary as well. This study simulated a number of important traffic scenes and compared the detection performance among different LiDAR installation locations. For example, it was found that the performance of LiDAR integrated into headlamps in detecting children is better than that of LiDAR on the roof. This paper reports the results of this comparison study and future challenges.

16 types of dangerous driving scenes among 310 categorized by JARI (Japan Automobile Research Institute) were selected for focussing on traffic scenes with obstacles between the host vehicle and the potential colliding object. Parking scenes were also used where pedestrian are hidden between or behind parked vehicles. All these situations create a blind spot which makes the lidar unable to detect the object.

All scenes were left-hand traffic



Six different objects including adult and child pedestrians, cycle, motorbike, vehicle and truck were used in the simulation, as well as 3 lidar locations in the car: on the roof, in the center of the bumpers, and finally in the lamps on the corners of the car. For each set of scene and object,

were measured the time when detection started, the period during which detection was interrupted, and the total time of detection.

3D simulations results:

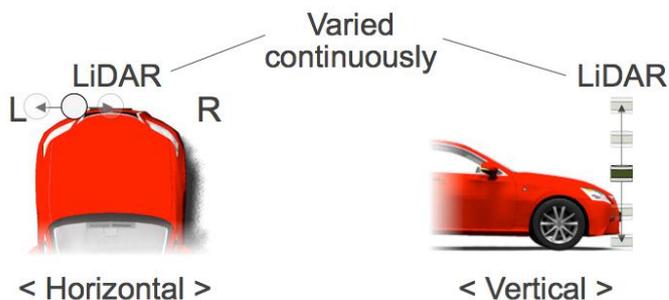
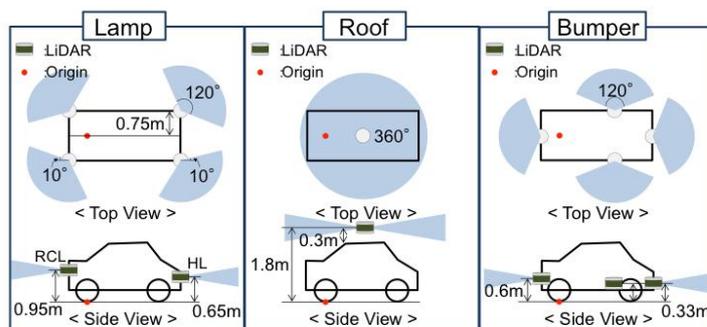
Of the 16 driving scenes, no difference was observed in five scenes. The causes of differences in the 11 remaining scenes are analysed :

- 6 scenes give advantages to the corner (headlamps) location.
- 4 scenes give advantage to the lidar mounting on the roof
- 1 scene give advantage to the lidar mounted in the bumper

Comparison of adults and children detection will be explored in detail in 2D simulations

Parking simulation show that the roof lidar is much more efficient for adults, but less efficient with children.

2D simulation results :



2D simulations examined horizontal and vertical detectable areas by continuously varying the position of the LiDAR. It was confirmed that the LiDAR units in the lamps could detect front and rear objects in a wide range even if there were obstructions in the surrounding area because the LiDAR units were located at the corners

of vehicle. If the LiDAR was located at a higher position such as on the roof, it was able to detect objects over surrounding obstructions in some cases.

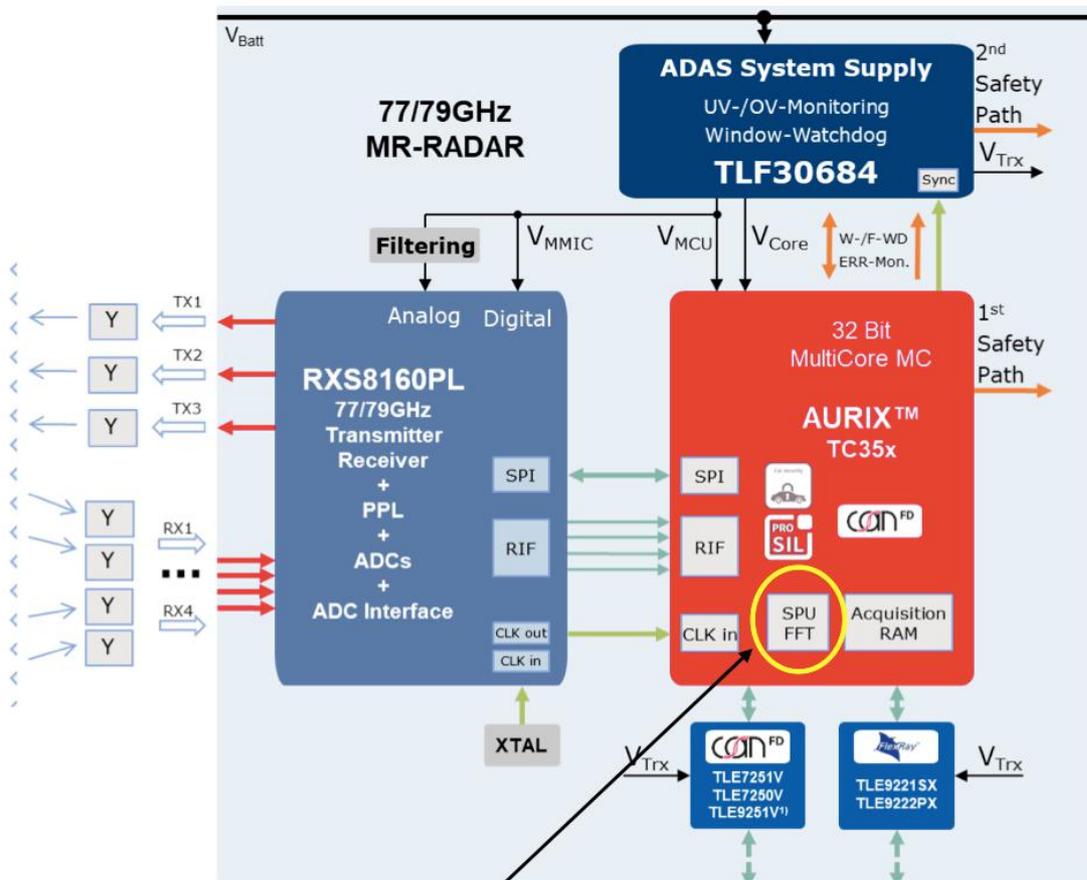
On the other hand, it was confirmed to be difficult for the LiDAR on the roof to detect a child near the host vehicle.

The next challenge is the verification of how the difference in the LiDAR's position will impact object classification, in addition to its impact on detection.

A breakthrough in Automotive Radar with Infineon Radar Signal Processing Unit

André ROGER, Infineon Technologies

Andre Roger, Infineon Technologies, introduces in this presentation a new family of Radar Processors, the TC33x, based on the design of a new chip set by Infineon as an extension of the well established AURIX™ microcontroller family. In an automotive 77GHz Radar market which has not yet reached its full maturity, Tier1s and OEM are looking for flexibility and customization possibilities, a challenging environment which is addressed by this new product offer.



Focus of the presentation

Without entering into the technical details of the presentation, it should be remained that by 2020, a new generation of radar sensors will be available, addressing both the tasks of driver assistance systems and also automated driving functions. Thanks to the scalability of the new AURIX™ radar microcontrollers, it will be possible to cover a wide range of applications up to the SAE level 4 for automated driving. The products will offer a high-performance SPU for higher resolution, fast response times, high interference robustness, improved object acquisition and low power consumption. Last but not least, the Radar microcontrollers also use the proven safety concept of the AURIX™ platform. To facilitate quick and easy design implementation, a comprehensive software framework and evaluation boards are available.

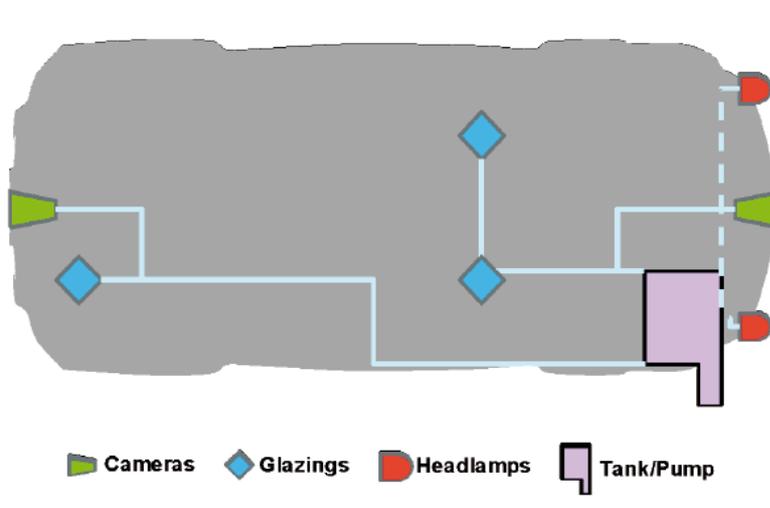
Ensure Sensors Vision, a Challenge for Vehicles Automatization Safety

Frédéric GIRAUD, Valeo Wipers Systems

This paper introduces the new generation of cleaning systems needed to allow future sensors to operate whatever the weather, the road conditions, the saison, and the environment conditions might be.

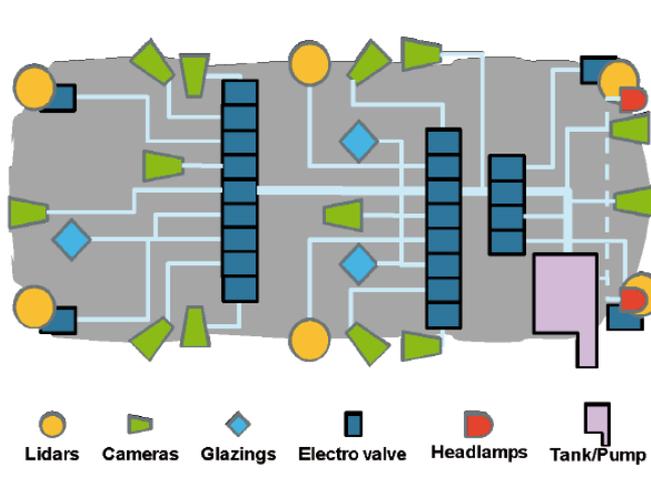
ADAS sensors and the automation of vehicles are considered as the future breakthrough in automotive safety. They mean more cameras and lidars at the front of the car, increasing the probability that snow, rain, dirt, or insects, will distort or mislead the capacity of interpretation of the fusion algorithm. It can be estimated that without efficient cleaning, autonomous driving will be hampered and limited 55 to 60 % of the time.

What is a good cleaning system ? It must be powerful and efficient, extremely quite, and reasonably priced. Today half of the ADAS sensors mounted in production cars have cleaning systems.



Example of an ADAS cleaning system for a passenger car

A true Level 4 Robotaxi or a Level 5 shuttle cleaning system becomes in comparison extremely complicated (see figure below)



Simplified example of Robotaxi cleaning architecture

In some cases, gathering in a unique module different sensors will be a real advantage, like a solid state lidar integrated in the Headlamp :



Benefits are : excellent integration, one supplier in charge of total system, price optimization thanks to sharing functions (orientation device, suppression of nozzle and sensor bracket).
Challenges : avoid interferences between headlamp light and sensor emission, additional glass for the lidar.

Although fully autonomous Robotaxis or shuttles require 24/24, all weather, all road conditons, all seasons new cleaning systems, solutions already exist which can face this challenge within certain limits : weight of the system (several KG considering the additional liquide needed), packaging (some liters if blowing or drying the lens is considered), and mainly the number of components and their necessary connections.

That's why Valeo is already worksing on breakthrough solutions limiting or suppressing the use of liquids and air, enabling also a better control and diagnostic of the visibiliti problems which might appear.

3D mapping and localisation using high-resolution radar and lidar

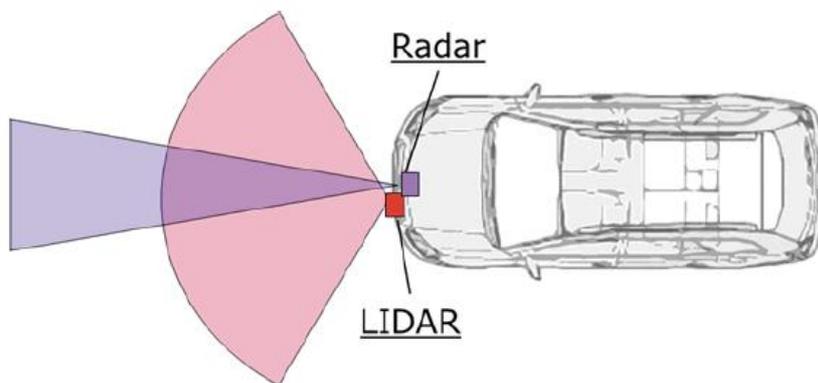
Johan DEGERMAN, Saferadar research

Vehicles that are capable of automating different aspects of the driving task are becoming increasingly powerful.

Lane keeping assist and autonomous cruise control systems are already handling some parts of the driving task autonomously.

One of the most challenging and vital parts of autonomous vehicle design is the problem of locating the vehicle with respect to the road and its surroundings. This is important in order to support lane-keeping, path planning, and prediction of other road users for threat assessment. The performance and robustness of these systems are often limited by the mapping and localization

accuracy. Mapping, in robotics, is a technique to store measurements of the environment to be used in a reference frame. The task of evaluating a position and orientation of an object, in this case a passenger car, versus the reference frame is called localization.



Vehicle platform

This paper presents mapping and localization results using a front scanning 3D radar and a front looking lidar. The implementation has been evaluated in a real scenario using a prototype vehicle equipped with the evaluated sensors, together with a reference position sensor. The localization error stays within 1m longitudinally and laterally for both sensors during this drive of 300m.

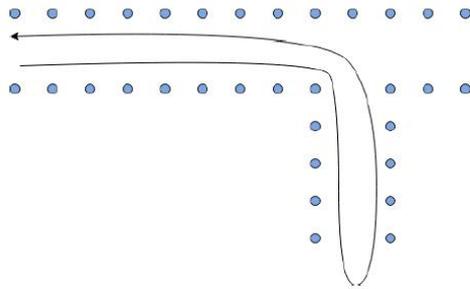


Fig. 9. A camera image from the T-intersection starting point and a sketch of the path driven during mapping and localization

The error in position is typically not larger than 0.2m which is also the grid voxel size. In turning maneuvers it increases to about 0.5m which is expected. However, the lidar was expected to have significantly better performance than the radar, but the radar had slightly better positioning. It is believed that the cause for the slightly high position error of the lidar is a misalignment error caused by transportation and the inability to perform a perfect calibration on track. The angular calibration is really important since the lidar maps the ground as well (In 2D mapping and localization the ground is typically removed, but since 3D mapping was performed, it was decided to keep it). This is why roll and pitch estimates are better for the lidar. Moreover, some synchronization/lagging problems were discovered when running lidar off-line. In the real-time mode the data rate was lower and timing problems were not evident.

The radar was synchronized directly on the FPGA which proved to be a very useful strategy. The radar performance was satisfactory, and the performance should reflect the capability of the single radar sensor using tx-scanning, proper calibration, and robust signal processing.

The logical next step would be to further develop the system to do SLAM (simultaneous localization and mapping), i.e. simultaneously estimate the map and the ego position without a reference sensor. Also, following the previous discussion it would be nice to integrate an auto-alignment and auto-synchronization functionality into the system, while doing full SLAM.

ROUND TABLE

The round table offers to the attendees several ways to combine lighting and ADAS.
The main conclusion: Lighting needs ADAS to lead the intelligent lighting and ADAS needs Lighting to help visibility of sensors and to fit in the future camera and lidar inside the headlamp



Gilles Le Calvez from VEDECOM, chairs the round table



**Participants at the round table, from left to right :
K.Fadel (Hella), W.Huhn (Audi), M.Pajon (Renault), J.Mathes (Valeo), R.Klädtker, M.Sasaki (Koito)**

NIGHT DRIVES



Dynamic Platform

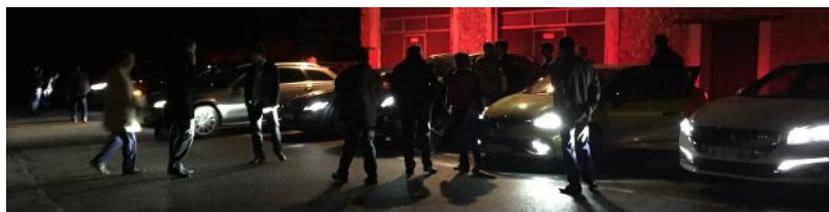
- Volvo XC90 with Valeo «Les Lunettes»
- Volvo X90 with Valeo Kinetic rear lights
- BMW X3 with LiFi
- Volvo V70 with Pixel lights
- Citroen C4 Picasso with Data environment perception as for an autonomous car from VEDECOM
- DS7 Crossback with Night Vision.

Urban Track

- VW Touareg with IQ.Light – Matrix LED
- Mercedes S-Class with Multibeam LED
- LSU Gen 1 with Improved High Beam (IHB)
- BMW MINI with Segmented glare free high beam "selective beam" and tail light "Union Jack"
- Audi Q8 with HD Matrix LED
- Opel Insignia with Matrix Headlamps
- HELLA with Liquid Crystal HD Headlamp
- Valeo X60 with Picture beam

Road Circuit

- VW Touareg with IQ, Matrix LED
- Mercedes C-Class 220 d Berline AMG Line with Multibeam LED
- Peugeot 508 with ARS
- Renault Megane with LED module with "flag shape" projector
- Audi A8 HD Matrix LED
- BMW i8 with Laserlight
- Mercedes-Maybach S-Klasse with Digital Light
- Audi A6 with Opti-Matrix Headlamp
- Ford Focus with Full LED Multifunctional Glare Free High Beam
- DS5 with High Current LEDs - SuperLED modules
- Renault Alpine with Bi-function low beam/high beam module with additional high beam
- Nissan Leaf with Direct Lens LED Headlamps (lighting technology).
- Renault Espace 5 with Assisted driving



EXHIBITORS

The 26 exhibitors who presented their products and services during the 2018 Vision Congress were delighted with the success of the event : an attendance of close to 600 participants, mostly high decision-makers from the lighting and ADAS industry. Contrary to the Paris Mondial auto show which took place during the same week, and which displayed to the general public the new trends in electrical cars, connectivity, autonomous cars, car sharing, Robot taxis, and new autonomous public transportation, this 2018 Vision exhibition focussed on improved safety now available in passenger cars thanks to digital lighting, and on improved comfort brought by ADAS.

The six take away points we retain from the 2018 VISION exhibitions are :

- Digital lighting will allow ADB to become a mass market option
- New technologies support the trend towards always slimer headlamps.
- Projection light technology is available, provided harmonized regulations can be decided by the regulation authorities.
- Digital lighting and ADAS are co-enablers and the 2 ecosystems will converge and become affordable, even for the medium car segment.
- Interior ambient lighting is becoming a hot subject.
- Innovation can disrupt even traditional functions like headlamp condensation management as demonstrated by the Condensation Management device (CMD) introduced by AML Systems and W.L. Gore.



- And finally, this exhibition was an opportunity for smaller or less known lighting players to come under the spotlights : Among them, some pionneering in new light sources like OLEDWorks, small family companies like Luxor, a French set maker founded in 1919, employing 115 people with a turnover of 12M euros, reknown for the quality of their products and their long acquired know-how and constant improvement of their processes, or Techniplas, with its light guides based on numerical optimization featuring an unprecedented homogeneity combined with very high system efficiency.

Pictures

https://photos.google.com/share/AF1QipM83F8OglqLGx5MecN90OXZPOiWWMcn2r1UviRI10EYFc6fYPn7XIUL88qGTSH3Lg/photo/AF1QipNKUVf2QnvFxKcEjxrgklsNt8EPWtEcVe_q_ose?key=TzV4cTJtS3lxNi1NekxwY25xOXhoZIRJamdoNkxn

Videos

<http://www.sia.fr/evenements/99-sia-vision-2018>

List of DVN Gold Members

28 Car Makers

Aston Martin, UK
Audi, Germany
Bentley, UK
BMW, Germany
Changan Design Center, Italy
FCA, USA
Daimler, Germany
Ford, Germany
GM, USA
Great Wall, China
Harley-Davidson, USA
Honda, Japan, USA
Hyundai, Korea, Europe
Jaguar-Land Rover, UK
Mahindra Mahindra, India
Nio, China
Nissan, Japan, Europe, USA
Opel, Germany
Porsche, Germany
PSA, France
Renault, France
SAIC TC,
UK
Shanghai-Volkswagen, China
Seat, Spain
Skoda, Czech Republic
Toyota, Japan, Europe, USA
Volkswagen, Germany
Volvo Cars, Sweden

19 Univ., labs, Consultants

Darmstadt university, Germany
DEKRA laboratory, Nederland
FEP, Franhauser, Germany
Fudan university, China
GranStudio, Italy
Hannover Leibniz Univ.(HOT), Germ.
Institut d'Optique Graduate School, Fr.
Karlsruhe Lighting Institute, Germany
LAB, France
Light Sight Safety, Belgium
Nuremberg university, Germany
Pacific Insight, USA
Parma university, Italy
Rensselaer university, USA
SLD Laser—formerly SoraaLaser
UMTRI, USA
University of California, Santa Barbara
YoungNam University, South Korea
Mr Shunxing Wang, China

39 Set Makers and Tier 1s

AL, Germany, USA
Denso, Japan
Elba, Romania
Farba, Turkey
FIEM Industries, India
Flex'N'gate, USA
Grakon, USA
Grote, USA
Harbin Good Time, China
Hella, Germany
Hyundai IHL, Korea
Ichikoh, Japan
J.W. Speaker, USA
Koito, Japan, Europe
Lear, USA, Europe
Lite-On, Taiwan
Lumax, India
Magna, USA, Austria
Microlight Auto Parts, Taiwan
Mobis, Korea
NAL, USA
Neolite ZKW, India
Nordic Lights, Finland
Odelo, Germany
Olsa, Italy
Plastic Omnium, France
Peterson, USA
Rebo Lighting, China, Germany
Shanghai Koito, China
SL Corporation, Korea
Stanley, Japan
Truck-Lite, USA
Valeo, France, Spain, China
Varroc, Germany, Czech R.
Wipac, UK
Xingyu, China
ZF-TRW
ZKW, Austria
Zodiac, France

61 Lighting Suppliers

A2Mac1, France
AKKA, France, Germany
AML Systems, France
Anrui Opto, China
Aspöck Systems, Germany
Auer-Lighting, Germany
Bicomoptics, China
Bühler Alzenau, Germany
Covestro, US, China, Europe
Dajac, USA
DBM Reflex, Canada
Delvis, Germany
Docter Optics, Germany
Dominant Opto Tech., Malaysia
EBW Electronics, USA
EcoGlass, Czech Republic
Elmos, Germany
Enmech-Mektec, Germany
Everlight Electronic, Taiwan, Germany
GXC Coatings, Germany
Holophane, France
IAV, Germany, USA
Infineon, Germany
Innotec Group, USA
Instrument Systems, Germany
Jenoptik, Germany
Keboda, China
LG Innotek, South Korea
LG Electronics, South Korea
LMT, Germany, China
Lumileds, Netherlands
Maxell Joei Tech, Japan
Merck, Germany
Mentor Graphics, Europe, USA
Mitsubishi Electric, Germany, Japan
Myotek Industries, USA
Nalux, Japan
Nichia, Japan
NXP, UK
ON Semiconductor, Europe, Asia, USA
Optis, France
Optoflux, Germany
Osram, Germany
Oxyphen, Switzerland
Panasonic, Japan
Proper Group, USA
Red Spot, USA
Sabic, USA
Samsung Electronics, Korea
Sapphire, USA
Sea Link International, USA
Segula Technologies, France, Austria
Seoul Semiconductor, Korea
Soraa Laser Diode, USA
Synopsys, USA, Germany
Texas Instruments, USA
TQ Technology, Taiwan
Vosla, Germany
Weidplas CH, Switzerland
WL Gore, USA
Zollner, Germany

MAIN DVN REPORTS List of Main DVN Reports 2008-2017

Hella company profile	Korea Lighting Market
Audi company profile	SL Corp profile
AL company profile	ADB/Matrix Beam
DRL, brand signature	J.W. Speaker Profile
Valeo company profile	2015 Geneva Auto Show
Koito company profile	ADAS and Lighting
China lighting market	India Car Industry and Lighting Market
The Wonderful World of Passenger Car lighting Regulations	Advanced Motorcycle Lighting
Tier 2and3 contribution on automotive lighting	IAA Auto Show 2015
ZKW company profile	ISAL 2015
Simulations in automotive lighting	Peterson Manufacturing
Mercedes-Benz profile	NAIAS Auto Show
LED technologies in Automotive Head lighting	Delhi Auto Expo 2016
LEDs Thermo-Electrics	DVN Delhi workshop
Interior Lighting	Geneva Auto Show 2016
BMW and lighting	Vision of lighting 2025-2030
Lighting and Driver Assistance	DVN Tokyo workshop
OLED technology	Automotive lighting Regulations worldwide
Materials in lighting	New ADB technologies
Laser Head lighting	Mondial Paris Auto Show
Peterson Manufacturing	VISION Congress Vehicle Lighting in USA
Automotive lighting Regulations worldwide	Vision of lighting 2025-2030
Simulation Tools	New ADB technologies
Israeli Startups	Interior Lighting
Jaguar Land Rover and lighting	ISAL symposium
IAA Frankfort autoshow	Shanghai autoshow

2018 reports

NAIAS and CES autoshows 30-01	DVN Tokyo Workshop 26-06
DVN Munich Workshop 27-02	Camera technologies 25 - 07
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