Future of Vehicle Lighting: The Role of Measurement Technology

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Vehicle design appeals in a special way to the emotions of customers. The intention is to create a connection with the owner of the vehicle through the vehicle's unmistakable appearance and strengthen customer loyalty to a vehicle brand in the long term. Vehicle lights have always played a key role in this regard, but they do so to a much greater extent today. People have always spoken of the headlights as the "eyes" of the vehicle, but today it is impossible to imagine the central stylistic element in vehicle design without lighting technology: Lighting is the new Chrome.

Today, LED and OLED technologies offer designers possibilities they could only dream of 10 to 20 years ago. Currently we are talking about illuminated radiator grilles at the front and edge-to-edge taillights at the rear (**Figure 1**), which can reach widths of up to 180 cm. And it is difficult to say where the future will take us.

Most of the new taillights consist of three segments, two of which are located in the vehicle body and one in the trunk lid, but there are already such lights that only consist of one piece.

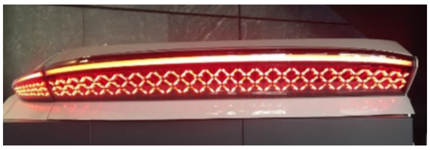

Figure 1: Edge-to-edge signal lamp as shown at ISAL 2023.

Examples of this could be admired at this year's ISAL Symposium from September 25th to 27th, 2023 in Darmstadt. ISAL is the world's most important forum for innovative vehicle lighting technology and ADAS, where international specialists exchange ideas about new technologies and designs for exterior vehicle lighting.

As a vehicle component that is essential for road safety, vehicle lights are subject to strict legal regulations for type approval testing that is required for the registration of a vehicle. These regulations can be found in UN-ECE R148 and R149 documents and primarily include photometric tests with a goniophotometer to prove compliance.

CIE publication no. 121 (the Photometry an Goniophotometry of Luminaires) distinguishes between three types of goniometers, Type A, B and C. Type A goniometers are used for the measurement of directional light sources, including vehicle headlights and signal lights. **Figure 2** shows a typical Type A goniometer.

The requirements for the goniometer mechanics for Type A machines are particularly high, especially when it comes to

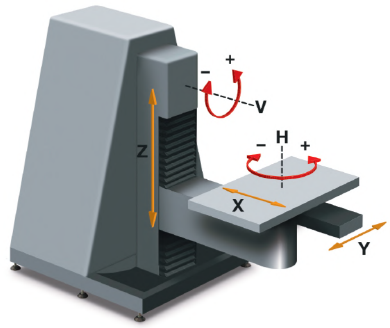

Figure 2: Motion directions type A goniometer.

repeatability, but more importantly absolute accuracy, which must be better than 0.05° for headlight measurements. However, it is immediately noticeable that the traditional Type A goniometer structure makes it difficult to align the light functions in the mounting position in the vehicle, especially if a DUT is very large and its certain optical reference points are at the extreme positions on the right or left of the DUT. There are basically different approaches to solving this problem.

It would be possible to use a conventional industrial robot. This has the advantage that there would no longer be the design-limited limitation of sample size, especially in edge-to-edge luminaires with optical reference points at extreme positions. However, it also has a number of possible serious disadvantages. First of all, the size and cost of a robot. To align a very large luminaire to extreme positions, an extremely long robot arm is necessary. The radius of action and space requirements with the safety area and room height are enormous and probably not practical in most cases. Compared to the conventional design of a goniometer, increased costs must also be expected.

Secondly, although high-precision industrial robots have good reproducibility, they do not achieve the absolute accuracy of the positioning of conventional goniometers. It is also to be expected that the absolute accuracy will continue to suffer as the size

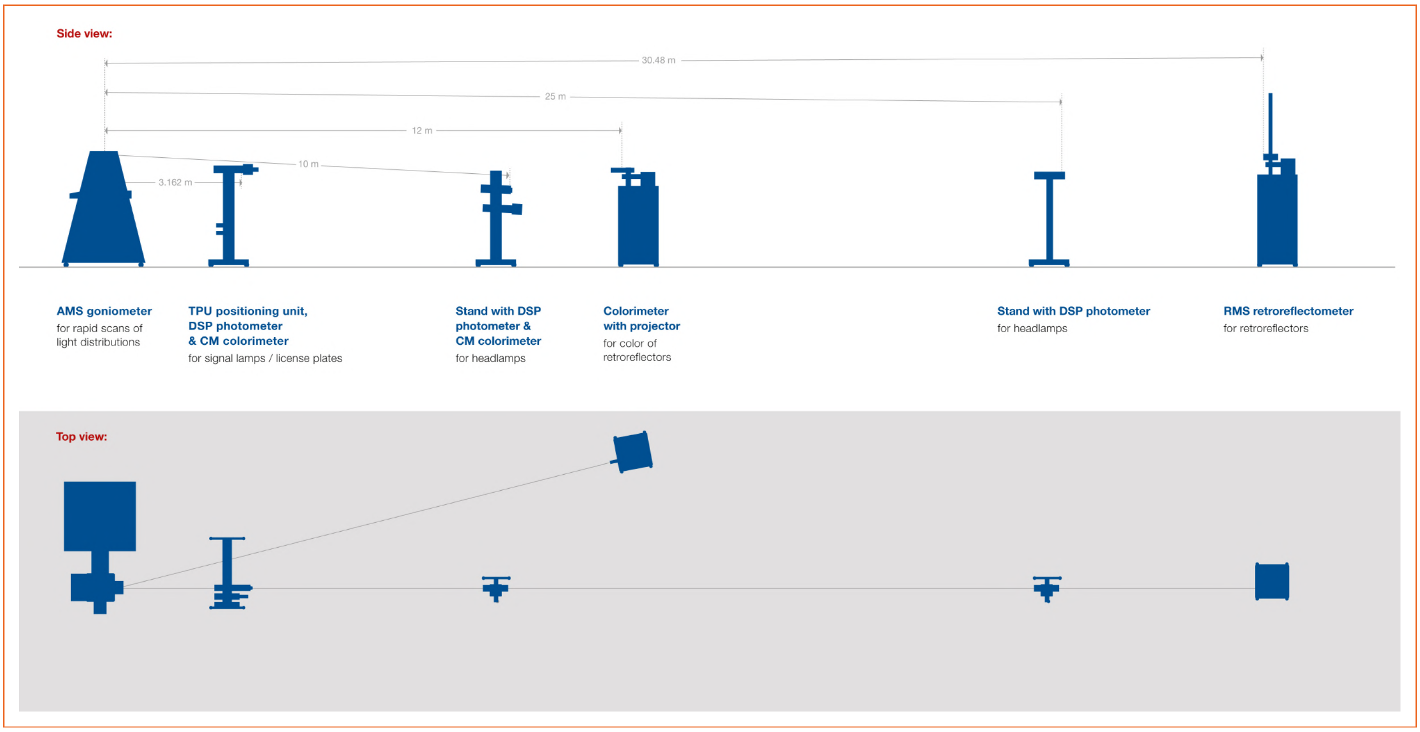

Figure 4: Schematic layout of complete lab set-up.

of the robot increases and the resulting mass increases. This means that robots may be suitable for measuring signal lights, but they do not offer the absolute accuracy for headlight measurements, where the requirements tend to increase in view of new ADB and matrix headlights.

Instrument Systems is therefore pursuing a different solution approach, namely adapting the traditional goniometer mechanics of a Type A system. It is suitable for the majority of applications, but also especially for signal light and headlight applications, since, for economic reasons an investment in two systems, i.e. one for signal lights and one for headlights, is not an option.

A design study based on the AMS 5000 high-performance goniometer was presented at this year's ISAL Symposium: Compared to a clear diameter of 900 mm, the swivel arm was extended by 550 mm to a clear diameter of 1450 mm. This allows luminaires up to approx. 2800 mm wide to be mounted with an optical reference point in the middle. The clear width allows the measurement and alignment of samples of about 1500–1600 mm wide lights with optical reference points at the extreme right or left position. The machine with the working title AMS 5000 XXL, which was shown at ISAL, is equipped with a larger test table on which larger samples can be aligned more easily and secured stably. This sample table can be made from a high-strength carbon composite material, which also saves weight and allows the maximum sample mass specified for this goniometer to remain largely the same, compared to a standard system despite the machine's significantly longer swivel arm. **Figure 3** shows a picture of the machine taken at the ISAL Symposium 2023 in Darmstadt. The DUT was provided by courtesy of Marelli Tolmezzo.

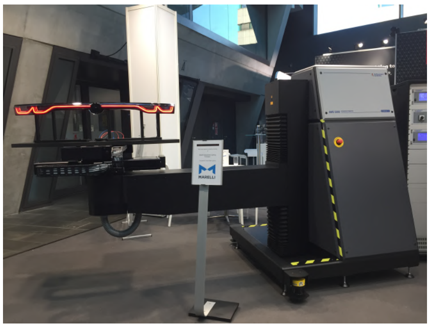

Figure 3: The AMS 5000 XXL goniometer, which was shown at ISAL, is equipped with a larger test table.

This goniometer will be available as a standard system by the end of 2023, but also serves as an example of the possibilities of adapting the goniometer mechanics to the requirements of the DUTs and of covering the widest possible range of applications with the design of the system.

The goniometer can be combined with different options: For example with ultra-fast DSP 200 photometers with sensor cooling and filter thermostatization. They are positioned at different measuring distances and enable quick measurements of light distributions on-the-fly. Or even with high-precision spectroradiometers of the CAS 140D series for determining the color locus and the most similar color temperature. Last but not least, with the RMS retroreflectometer 1200 for reflector measurement according to ECE R3, 27 and 150 as well as other accessories. Everything together forms a complete turnkey system for type testing of headlights, signal lights and reflectors (**Figure 4**).

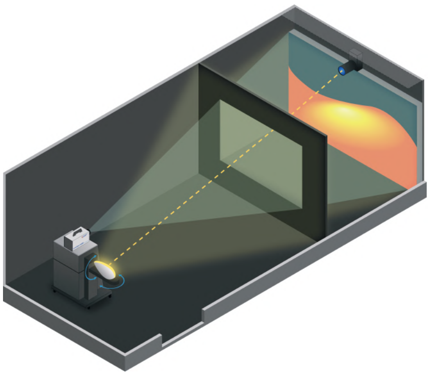

Figure 5: Schematic view of AMS Screen Imaging System.

In combination with the 2D imaging camera LumiCam 2400B/4000B and the calibration source ACS 630, the expansion to a screen photometer for the development-assisting, highly efficient, and rapid determination of ADB, Matrix, AFS headlight distributions is also possible (**Figure 5**). ■

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