EMPIR Call 2016 – Energy, Environment, Normative and Research Potential

Selected Research Topic number: **SRT-n05**
Version: 1.0

Title: Pavement Surface Characterisation for Smart and Efficient Road Lighting

Abstract

Road lighting installation requirements for motorised traffic consider the road luminance level as the key standard parameter in order to achieve adequate visual conditions and traffic safety. Currently, road surface reflectance data, which are more than 40 years old and incomplete, are used for these calculations. However, the properties of pavements have progressively changed over this time, leading to standard-based lighting designs which do not adequately address visual optimisation, energy efficiency and safety. Proposals addressing this selected research topic would develop and provide new and revised traceable measurement methods and data for pavement characterisation, design calculations and reference values to support European standards (EN 13201 'Road lighting' series) and CIE guidance.

Keywords

Road lighting, road surface photometry, road safety, energy saving, smart lighting, smart cities, innovative pavements

Background to the Metrological Challenges

Road lighting standards require defined levels of road luminance to ensure safety and visibility for all road users. In order to correlate the luminous flux incident on the road surface to its luminance, the reflectance characteristics of the surface (luminance coefficient or the reduced luminance coefficient) need to be known. Knowledge of the road surface's reduced luminance coefficient is important to optimise the energy performance of the installed lighting (EN 13201-3 'Calculation of performance' and EN 13201-5 'Energy performance indicators'), and also in the evaluation of glare (EN 13201-3) and to improve safety and comfort during the night (smart cities).

Depending on the layout of the road lighting installation EN 13201-3 specifies two sets of data, but only provides the angular directions and not the values. The first set of data are described in CIE tables CIE 144:2001), however they were derived from measurements carried out more than 40 years ago, and although these values have been adopted as a *de facto* standard in a number of countries, this solution is not adequate for optimisation of vision performance and energy consumption of modern road lighting installations. Pavement properties and the photometric properties of road materials have changed over the years and some studies show that using the current standards, based on available CIE data, can lead to errors in the average luminance of 30 % to 50 % or more. New types of luminaires, especially those based on solid state lighting (SSL), can exhibit a very sharp luminous intensity distribution and whilst this simplifies the optimisation of the energy consumption, it also increases the influence of the road surface characteristics in reflection, especially when considering the luminance uniformities. LED technology offers the opportunity for smart lighting able to adapt both the intensity and direction of the flux at any time according to the brightness and specularity of the road pavement. This highlights the need to increase the accuracy of the designs of lighting installations, to reduce over-dimensioning and for reliable verification of the design performance. New sets of defined angles are required to better evaluate glare for both drivers and pedestrians (to support EN 13201-2:2015 'Performance requirements' and EN 13201-3:2015), for correct evaluation of the dispersed light in the upward direction, and for applied vision models such as the STV (Small Target Visibility) developed in CIE TC4-36 which aims to optimise the visibility of small objects on the road thus minimising the road luminance level required. New types of road material, including surfaces for road drainage or coloured pavements, require new measurements and specific tables of the reduced luminance coefficient. The spectral radiant coefficient also needs to be considered in particular related to the mesopic concept (CIE191:2010), which has been introduced in some national standards and international guidelines (CIE 206:2014).

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Systems for measurement of the photometric characteristics of pavements is now under consideration by CIE TC4-50, which has identified the following areas as requiring further development: i) standard angular conditions of measurements are a constraint in portable instruments and determining a limited set of values, or a standard method for interpolation is important for commercial instruments; and ii) without standard guidelines the reliability of measurements is unknown. There is a therefore a need to revise and extend the reference tables in the current CIE database and to implement them in European and CIE documents.

Appropriate road lighting and public lighting is necessary to ensure safe travel and good visibility for all road users and there is also a need to minimise the system and management costs, energy consumption and environmental impact through design optimisation of the lighting. This can only be achieved through better design based on more reliable data on road surface characteristics harmonised with current road lighting standards to provide higher visual quality to all road users; and a standardised procedure for measurement of road surface reflectance properties in the laboratory and on-site will improve measurement uncertainty and minimise over-dimensioning of road light installations to ensure energy efficiency and a safer environment.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on the development of metrology research necessary to support standardisation in the photometric characterisation of road surfaces.

The specific objectives are

1. To propose optimised measurement geometries for the characterisation of photometric quantities for road surface materials (to support EN 13201 ‘Road Lighting’ and its future revisions).
2. To propose technical and metrological specifications for instruments used to measure luminance and (reduced) luminance coefficients of road surfaces in laboratories or on-site, including methodologies for calibration, establishing traceability and evaluating the measurement uncertainty.
3. To develop pre-normative guidelines for measurement methods and procedures for the future evolution of European standards to include aspects such as mesopic visual conditions (CIE191:2010), reduced obtrusive light and reduced light pollution of road lighting installations.
4. To develop pre-normative guidelines for photometric characterisation of road and pavement surfaces, including factors such as aging of road surfaces, wet conditions, spectral properties, diffusion of adaptive lighting systems, luminaire luminous intensity distribution and effects of measurement uncertainty in tolerance calculations.
5. To contribute to the standards development work of the technical committees CEN TC169/WG12 and CIE TC4-50 through the provision of data, methods, guidelines and recommendations. In particular to provide traceable date related to the new geometries and materials for inclusion in updated photometric tables of pavements in the international CIE database. To ensure that the outputs of the project are aligned with their needs, communicated quickly to those developing the standards and to those who will use them (e.g. lighting engineers, road designers), and in a form that can be incorporated into the standards at the earliest opportunity.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.6 M€, and has defined an upper limit of 0.8 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies, in particular CEN TC169/WG12 and CIE,
- Transfer knowledge to the legislators responsible for road safety, the road construction industry, and the manufacturers of luminaires.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.