International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

1 Adaptive, Intelligent and Dynamic Lighting

1.1 Description of research

With the advent of advanced control systems incorporating LED sources, the opportunity to provide fully adaptable lighting is a significant direction being considered by industry. The term adaptive lighting refers to the changing of the light source condition, whether overall level, colour, light distributions or some other metric based on the needs of the environment. The adaptability of a lighting system can be classified into four levels:

- Level 1 – Adaptation using time schedules based on statistics
- Level 2 – Adaptation on demand using local sensors or individual local controls
- Level 3 – Adaptation with links to intelligent systems such as building automation systems (BAS) and intelligent transport systems (ITS) on selected roadways
- Level 4 – Adaptation combining the options of Levels 2 and 3, for example:
  - Scheduled changes in light source colour or level to mimic daylight patterns, with or without local occupancy detection, task tuning, or daylight-harvesting
  - Adaptation with links to ITS systems on all roadways with electrical and lighting management systems (ELMS) control
  - Luminance monitoring
  - Lighting-on-demand – lights that are activated by immediate need and otherwise dimmed or off, e.g. with Connected Vehicle Technology or in response to local occupancy signals
  - Smart city and smart building applications

At this point, while the technology exists to provide all of these capabilities, the application and usability of these adaptive approaches has not been considered. In this topic, we promote the consideration of user needs together with environmental considerations and energy usage.

1.2 Key research questions

- What is the impact of adaptive lighting on user behaviour or reactions, such as occupants' space perception or driver safety?
- How should the system adapt itself to the circumstances to provide the optimal lighting? For example:
  - Could the system detect individual needs for varying visual conditions?
  - Could roadway lighting vary depending on traffic composition, traffic density, and weather conditions?
- What are the relations between lighting settings and user safety and comfort?
- Which types and levels of dynamics are acceptable in a lighting installation?
- Which types of input and feedback (e.g. road surface luminance monitoring, photocells, presence detection, algorithms for integrated multi-sensor input, automated fault detection) are necessary to ensure system usability?
- What are the energy and operational costs and benefits of adaptive lighting?
- Could adaptive exterior lighting have ecological benefits beyond energy savings?

1.3 Justification of the need for the proposed research topic

The potential benefits of an adaptive lighting system (sometimes called "smart lighting") are significant. There is the possibility for a significant reduction in energy usage, sky glow, light

trespass and maintenance costs while still maintaining user safety. Furthermore, the energy benefits of adaptive lighting can be used to ensure that energy code limits on installed lighting power density do not restrict the ability to deliver the quality and quantity of light when needed.

The technology to provide adaptive lighting is already in the marketplace and being accepted by some jurisdictions. The proper use of these technologies however has not been identified, so that there remains a risk that some applications might adversely affect users. In order to ensure that no harm is done with the application of these systems there is a significant need to answer these research questions.

1.4 Related current activities in CIE

TC 4-51	Optimization of Road Lighting
TC 4-52	Lighting for Pedestrians: New Empirical Data

1.5 Existing CIE publications

CIE 115:2010	Lighting of Roads for Motor and Pedestrian Traffic
CIE 205:2013	Review of Lighting Quality Measures for Interior Lighting with LED Lighting Systems
CIE 222:2017	Decision Scheme for Lighting Controls in Non-Residential Buildings