

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Guillaume Dotreppe**

The public defense will take place on **Tuesday 24th March 2026 at 5pm** in room **I.0.03** (Building I, VUB Main Campus)

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**MIND THE BEAM: EXPLORING PHOTOMETRIC LIMITS IN VEHICULAR
VISIBLE LIGHT COMMUNICATION**

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Abstract of the PhD research

Modern vehicles increasingly rely on communication systems to improve road safety, reduce traffic congestion, and support advanced driver aid systems. These systems allow vehicles to exchange information about their state and surroundings, such as driving speed, driving direction, distance to other vehicles, or whether autonomous driving is active. By sharing this information, vehicles can warn each other about emergency braking, coordinate platoons that travel closely together to reduce air resistance and improve efficiency, or receive infrastructure-based messages, e.g. assistance at intersections indicating whether it is safe to proceed. Together, this helps to prevent accidents, improve traffic flow, and further support autonomous driving. However, traditional radio-based communication can become unreliable in dense urban environments, where interference and congestion are common.

Vehicular Visible Light Communication, or V-VLC, offers a solution by using vehicle lights to transmit data, enabling a complementary communication path. In this approach, existing lighting devices serve a dual purpose, providing both illumination and data communication. Because visible light does not interfere with radio signals and can be deployed without competing for regulated channels, V-VLC can enhance the reliability of safety-critical communication links, particularly in challenging traffic conditions.

Designing robust V-VLC systems requires accurate models that predict how light based communication behaves on the road. These models depend strongly on the representation of vehicle lights. Most existing approaches simplify headlights as idealised point sources that emit light evenly around a central direction. While convenient, this assumption does not reflect the true behaviour of automotive low beam headlamps used for forward communications, which produce complex and asymmetric light patterns shaped by strict lighting regulations.

This thesis improves on the realism of V-VLC models by analysing standard photometric practices, that is, the methods used to measure and characterise real lighting systems. Through a novel luminaire representation, traditional methods used to determine when simplified assumptions are valid and when they break down, this work proposes improved standardised photometry practices. By incorporating these insights into wireless communication models, improved strategies for representing vehicle headlights in V-VLC models are presented. A key outcome is the use of representative light distributions that better capture real headlamp behaviour without excessive modelling complexity.

The results show that simplified models often overestimate communication performance. In contrast, the proposed approach provides more cautious and reliable predictions, which are particularly important for safety-critical applications. As a result, this work strengthens confidence in V-VLC performance assessments and supports the development of more robust vehicle communication systems for real world deployment.