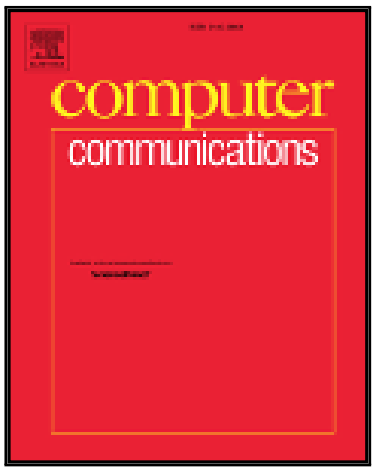


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# Exploring GLOSA Systems in the Field: Technical Evaluation and Results

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**Abstract**

Green Light Optimal Speed Advisory (GLOSA) systems are believed to be able to lower $CO_2$ emissions, fuel consumption, and travel times by avoiding unnecessary stopping at intersections. Approaching vehicles are given speed recommendations based on current and future traffic light signal phase timings. These systems have been widely evaluated by means of simulation and, while most research focuses on the impact assessment of GLOSA along with environmental influences, minor attention was drawn to the holistic technical evaluation of included sub-modules and implementations.

In this extended version of our IEEE VNC 2016 publication [1], we present a holistic concept for the technical evaluation of IEEE 802.11p-based GLOSA systems. We first give a comprehensive survey on GLOSA systems and studies all around the world and identify remaining problems. We introduce metrics to cover the whole spectrum of GLOSA operations and particularly focus on (modeling) problems we encountered in the field that are often not taken into consideration in simulation studies. We demonstrate how this concept can be used to evaluate the real-world GLOSA system tested in the European Commission co-funded field trial DRIVE C2X. Results derived from Field Operational Test (FOT) data show that our metrics are well-suited to assess the performance of the GLOSA system, and also to identify sources of potential problems or bottlenecks.

Based on our findings, we argue that most GLOSA simulation studies are too optimistic in terms of communication performance. Lastly, we give recommendations on how real-world GLOSA systems can be further improved to support a sufficient level of performance.

*Keywords:* GLOSA, EAD, ESC, DRIVE C2X, Field Trial, Evaluation

## 1. Introduction

Green Light Optimal Speed Advisory (GLOSA) systems are among the first Cooperative Intelligent Transport Systems (C-ITS) applications to utilize Car-to-X (C2X) communication technology. Giving speed advice to the driver when approaching a traffic light is believed to allow for introducing environmental benefits through lowering $CO_2$ emissions and fuel consumption [2, 3, 4]. To this end, information about traffic light signal phases is broadcast to approaching vehicles in the vicinity of the intersection by means of Map Data Messages (MAP) and Signal Phase and Timing Messages (SPAT) [5]. Speed recommendations are then calculated by the vehicle to pass the traffic light during green phase to avoid unnecessary stops and acceleration maneuvers, when possible. These systems can function even at low market penetration as they do not rely on other vehicles and are therefore envisioned to act as an enabler of Car-2-X technology.

GLOSA systems have received much attention both from industry and academia. They were tested in Field Operational Tests (FOTs), evaluated analytically or by means of simulation. Unfortunately, we observe that many of these studies are carried out independently of each other, and, for example, that simulation studies often neglect insights gained from FOTs [6]. This can cause these studies to be too optimistic in terms of communication performance and subsequently to overestimate the environmental impact of GLOSA systems. In addition to that, many studies only focus on a specific part of the GLOSA system, abstracting away from effects that can considerably affect the recommendations given to the driver.

In this paper, which is an extension of our IEEE VNC 2016 publication titled "Technical evaluation of GLOSA systems and results from the field" [1], we take a holistic approach. This includes all related GLOSA modules in the On-Board Unit (OBU) as well as the Roadside Unit (RSU) in order to evaluate their performance based on data from an extensive field test within the DRIVE C2X [7] project. We extend our previous work by providing more insights into GLOSA application and algorithms, including HMI design, as well as detailed field test set-up. We present a comprehensive survey of related work all around

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