ABSTRACT

Title: Infrastructure planning for connected and autonomous vehicle operations considering travel demand and sustainability
Author: Sania E. Seilabi, Ph.D.
Institution: Purdue University
Committee Chair: Samuel Labi

The last century has witnessed increased urban sprawl, motorization, and the attendant problems of congestion, safety, and emissions associated with current-day transportation systems. Contemporary literature suggests that emerging transportation technologies, including vehicle autonomy and connectivity, offer great promise in addressing these adversities. As such, highway agencies seek guidance on infrastructure preparations for connected and automated vehicle (CAV) operations. A key area of such preparations is the management of lanes to serve CAVs and human-driven vehicles (HDVs), including the deployment of dedicated lanes for CAVs. There is a need to address the demand and supply perspectives of CAV preparations. On the demand side, agencies need to model the trends and uncertainties of CAV market penetration and level of autonomy during the CAV transition period. On the supply side, agencies need to schedule the CAV-related roadway infrastructure in a way that progressively addresses the growing demand.

In addressing these research questions, this dissertation first carries out an economics-based lane allocation for CAVs and HDVs in a highway corridor by determining the optimum number of CAVLs by minimizing road user cost. Next, the dissertation carries out such an allocation considering both economics (agency cost) and the environment (community emissions cost). Third, the dissertation addresses elements of social and economic sustainability using a CAV-enabled tradable credit scheme that minimizes user travel time subject to social equity constraints. Further, this dissertation provides guidance on how CAV-dedicated lanes, in conjunction with market-based tradable travel credits, could enable the road agency to achieve maximum efficiency of the existing road infrastructure in the CAV transition period. The study framework can serve as a valuable decision-support tool for road agencies in their long-term planning and budgeting in anticipation of the CAV transition period. The key outcome of the framework is an optimal schedule for deploying CAV-dedicated lanes over a given analysis period of several decades in a manner commensurate with CAV demand projections and sustainability-related objectives and constraints.