The recent development in communication technologies facilitate the deployment of connected and automated vehicles (CAV) which are expected to change the future transportation system. CAV technologies enable vehicles to communicate with other vehicles through vehicle-to-vehicle (V2V) communications and the infrastructure though Vehicle-to-infrastructure (V2I) communications. Since the real-world CAV data is not currently available as of today, simulation is the most commonly used platform to evaluate the future V2X system. Although several studies evaluated the effectiveness of CAVs in a small roadway network, there is lack of studies analyzing the impact of CAVs at the network level by considering both freeways and arterials. Also, none of the previous studies have attempted to differentiate the benefits of CAVs over only automated vehicles (AVs) by incorporating multiple preceding vehicles' information (i.e., acceleration, position, etc.). On the other hand, most of the simulation-based studies assumed the uninterrupted communication between vehicles in the CAV environment which might not be feasible in reality. Hence, there is still a research gap that exists for which this study tried to fill this gap. Therefore, this study developed a calibrated, and validated large-scale network for the deployment of CAV technologies by utilizing Dynamic Traffic Assignment (DTA) model in Orlando metropolitan area, Florida, using Multi-Resolution Modeling (MRM) technique. Also, the study proposed a signal control algorithm through V2I technology in order to elevate the performance of CAVs at intersections. Different car-following models were utilized to approximate different CAV technologies (CAV, AV, and CV (connected vehicle)) in simulation environment. Hence, the study analyzed the benefits of CAV over AV with different market penetration rates (MPRs). Furthermore, the study considered the real communication system along with the field traffic condition by utilizing Dedicated Short-Range Communications (DSRC or IEEE 802.11p) and wireless access (IEEE 1609 protocol) for the application of vehicle ad-hoc network (VANET). To this end, the study evaluated the safety effectiveness of different communication protocols under the CAV environment. Aimsun Next and SUMO & OMNET++ based Veins simulator were used as the simulation platform. Different car-following models, signal control algorithm, and communication system were coded by using application programming interface (API) and C++ language. For the traffic efficiency, the study utilized travel time and travel time rate (TTR) while for the safety evaluation, different surrogate safety measures; speed and crash-risk models were used. Also, several statistical tests (e.g., t-test, ANOVA) and modeling techniques (e.g., generalized estimating equation, logistic regression, etc.) were developed to analyze both safety and mobility. The results of this study implied that CAV could improve both safety and efficiency at the network level with different MPRs. Also, CAV is more efficient compared to only AV in terms of both traffic safety and mobility. Different communication protocols have significant effect on traffic safety under the CAV environment. Finally, the results of this study provide an insight to transportation planners and the decision makers about the benefits of CAV at the network level, different CAV technologies, and effect of real communication system.

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