This dissertation focuses on examining three problems at the intersection of smart city operations and innovative transportation technologies. In particular, the first two chapters study the potential effects of autonomous vehicles (AVs) on highway congestion and downtown parking, respectively. The third chapter of this dissertation studies the effect of ride-hailing passenger drop-offs on downtown rush-hour congestion and parking.

In the first chapter, I investigate the effects of AVs on highway congestion. AVs have the potential to significantly reduce highway congestion because they can maintain smaller intervehicle gaps and travel together in larger platoons than human-driven vehicles (HVs). Various policies have been proposed to regulate AV travel on highways, yet no in-depth comparison of these policies exists. To address this shortcoming, I develop a queueing model for a multilane highway and analyze two policies: the designated-lane policy (“D policy”), under which one lane is designated to AVs, and the integrated policy (“I policy”), under which AVs travel together with HVs in all lanes. I connect the service rate to intervehicle gaps (governed by a Markovian arrival process) and congestion, and measure the performance using mean travel time and throughput. My analysis shows that although the I policy performs at least as well as a benchmark case with no AVs, the D policy outperforms the benchmark only when the highway is heavily congested and AVs constitute the majority of vehicles; in such a case, this policy may outperform the I policy only in terms of throughput. These findings caution against recent industry and government proposals that the D policy should be employed at the beginning of the mass appearance of AVs. Finally, I calibrate the model to data and show that for highly congested highways, a moderate number of AVs can make a substantial improvement (e.g., 22% AVs can improve throughput by 30%), and when all vehicles are AVs, throughput can be increased by over 400%.

In the second chapter, I study how AVs may change the morning commute travel pattern and improve downtown parking. I develop a continuous-time traffic model that takes into account key economic deterrents to driving, such as parking fee and traffic congestion, and characterize the departure time and parking location (downtown or outside downtown parking area) patterns of commuters in equilibrium. To illustrate the results, the model is calibrated to data from Pittsburgh. For the calibrated model, my analysis shows that all AV commuters choose to park outside downtown, increasing both vehicle hours and vehicle miles traveled as compared to the case with all human-driven vehicles. This change increases the total system cost and suggests a potential downtown land-use change (e.g., repurposing downtown parking spots to commercial and residential areas) in Pittsburgh after mass adoption of AVs. To reduce the total system cost, a social planner may be interested in regulating commuters’ decisions by adjusting parking fees and/or imposing congestion tolls as a short-term measure, or adjusting infrastructure, e.g., converting downtown parking spaces to curbside drop-off spots for AVs. The results indicate that these measures can reduce the total system cost substantially (e.g., up to 70% in my calibrated model).

In the third chapter, I investigate how ride-hailing may change the morning commute travel pattern and improve downtown parking. Similar to the second chapter, I develop a continuous-time traffic model that
takes into account key economic deterrents to driving, such as parking fees and traffic congestion, and characterize the departure time patterns and transportation modes (driving or ride-hailing) of commuters in equilibrium. To illustrate the results, the model is calibrated to data from Pittsburgh. For the calibrated model, my analysis shows that as drop-off congestion increases, the number of commuters who switch from driving to using ride-hailing increases, which leads to an increase in vehicle hours traveled as compared to the case when all commuters drive. This change increases the total system cost and proposes a potential opportunity for repurposing downtown parking spots to commercial and residential areas in Pittsburgh. To reduce the total system cost, a social planner may be interested in regulating commuters’ and the transportation network company’s decisions by adjusting parking fees and/or imposing drop-off tolls as a short-term measure, or adjusting infrastructure, i.e., increasing the number of curbside drop-off spots for ride-hailing vehicles. The results indicate that these measures can reduce the total system cost substantially (e.g., up to 77% in the calibrated model).