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# Demand-Side Management of Auto Traffic

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POLICY BRIEF

## BACKGROUND AND OBJECTIVES

Fueled by burgeoning e-commerce, urban parcel delivery (UPD) has emerged as a high growth market that is undergoing rapid technological change, particularly in the business-to-consumer segment. New classes of vehicles such as drones, droids, and autonomous ground vehicles, combined with new delivery models featuring crowdsourcing, parcel lockers, and mobile lockers, will enable a significant shift away from the conventional model of a dedicated delivery person operating a van. To reach the full potential of these changes to reduce costs and increase convenience, it is necessary to develop a complementary set of demand management strategies that will enable the next-generation parcel delivery system to mitigate current traffic congestion problems and avoid creating new ones. The project aims to (1) quantify the current and anticipated future contributions of UPD to urban congestion and related problems, such as traffic accidents and (2) identify opportunities for incentivizing consumers and delivery services to modify their behaviors to reduce the congestion impacts of UPD. To accomplish these objectives, the focus is on (1) demand models of e-commerce behaviors, (2) measuring the impact of delivery service operations on urban congestion using macroscopic fundamental diagrams, and (3) urban operations of drone deliveries to assess their potential for removing parcel delivery demand on roads. The modeling system will be used to assess the congestion reduction benefits of a range of policies geared toward encouraging consumers and service providers to adopt behaviors that reduce the congestion caused by urban delivery. In addition, an analytical framework for assessing the safety impacts, including non-recurring congestion reductions, of innovative UPD technologies is proposed. The method for identifying UPD crashes and statistical models for estimating UPD crash risks at TAZ levels by given demographic, roadway, and traffic conditions.

## METHODOLOGY

The models for urban congestion developed from this research project are sensitive to urban delivery activities. They can assess how current delivery activities contribute to urban congestion and how the alternative delivery activities alleviate traffic congestion in urban areas in terms of congestion reduction percentage or reduction of vehicle hours. The zone-based incident/accident models can be used to estimate incidents/crashes under current delivery activities and reduction of incidents/crashes under alternative delivery scenarios.

This research starts with modeling the demand of e-commerce behaviors by analyzing how different characteristics are impacting food or non-food travel behaviors before and after pandemic. We conducted a May 2020 follow-on panel survey (313 households) for one week early in the pandemic, supplementing an April to May 2018 household travel survey (n=3,956 households) conducted by the Sacramento Area Council of Governments (SACOG). Logistics regression is used in the first part to evaluate how different characteristics is impacting the travel behaviors for shopping. With increasing demand of online shopping results from burgeoning e-commerce and pandemic, the research follows by measuring the impact of delivery service operations on urban congestion using Macroscopic Fundamental Diagrams. Then, we work on urban operations strategies of drone deliveries to assess their potential of removing parcel delivery demand on the roads. More specifically, we propose a framework of UAV system traffic management in the context of parcel delivery in low-altitude urban airspace, including clustering-based UAV path planning, systematic UAS traffic management with conflict resolution, and mechanism design for airspace resource allocation. Lastly, we develop an analysis framework for assessing the safety impacts and non-recurring congestions of UPD modes, identify UPD crashes from historical crash database, and develop preliminary models to predict the UPD crash likelihood based on demographic, roadway, and traffic factors.

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**RESEARCH FINDINGS**

For each of the four parts summarized above, we present the main findings and contributions. In the first part of demand models of e-commerce behaviors, our results show the solution to 1) how demographic characteristics affect pandemic shopping behavior, 2) how near-term shopping behaviors might play out in the longer term, and 3) new opportunities for partnering between public and private stakeholders around the curb. For example, model results indicate that prior to the pandemic, higher income households were less likely to shop only online for non-food items, whereas after the pandemic these same households began substituting in-person trips for online purchases.

The second part of the study analytically approximates the impact of DSO on network capacity and compare the theoretical prediction to the network flow observed in simulation of street traffic. The impact of DSO on urban traffic was measured within the Macroscopic Fundamental Diagram (MFD) framework. The study shows the simulation results and the theoretical prediction for capacity with different numbers of DSO double-parked stops. The prediction from the model is in good agreement with the results of the simulation. In the future, the shape of the entire MFD as the result of DSO operations can be modeled. Second, a large number of possible DSO scenarios and their impacts for various network configurations can be modeled. Third, the MFD model can be used to compute arrival delay and air pollution values that result from delivery service operations.

In the third part of urban operations strategies using drone delivery, we efficiently utilize the low-altitude airspace resources, and propose a framework of UAS traffic management including clustering-based UAV path planning, systematic UAS traffic management with conflict resolution, and mechanism design for airspace resource allocation. This work enables efficient traffic management of UAV systems when traffic demand partially shifted to the low-altitude urban airspace. It mitigates the congestion impact from truck and van traffic, as well as reduce costs and travel times. In addition, the familiar issues of urban street congestion, in the future we may also see congestion above the city from UAV traffic, as use of these vehicles for urban package delivery and other purposes intensifies.

In the last part of study, we propose a framework for assessing safety impacts, including non-recurring congestion reductions, of innovative UPD technologies. The framework can be used to comprehensively evaluate the benefits of new UPD modes and provide decision making support to develop and implement the new technologies. This study also developed a procedure based on Fuzzy language processing technologies to identify UPD crashes from historical crash databases. The identification procedure addresses the most significant challenge in UPD safety management and analysis and provides reliable UPD crash data. A statistical model was developed based on the identified UPD crashes that estimates UPD crash frequencies for a TAZ given demographic, roadway, and traffic characteristics of the TAZ.

**POLICY AND PRACTICE RECOMMENDATIONS**

The models of urban congestion developed from this research project can benefit practitioners from several perspectives. 1) By modeling the demand of e-commerce behaviors, the results can aid planners and policymakers in understanding both short- and long-term effects of pandemic-induced changes to shopping behavior in mid-sized cities/regions. The information can also give recommendations to practitioners when making decisions. For example, the results recommend that it will be important to track growth of the e-commerce industry in the longer term, to better understand if e-commerce will replace existing trips, complement them, or induce more new trips and to identify whether delivery drivers or individual customers will be making greater use of the curb space in front of commercial businesses. It will be key to balance the needs of all types of curb users and keep safety — both viral and traffic-related — a priority. At present, many COVID-19 testing facilities are currently using re-purposed surface parking lots, providing examples from which retail businesses and planners can learn. In the longer term, the re-purposing of parking lots to higher and better uses, such as housing, is warranted. 2) Measuring the impact of DSO on network capacity gives practitioners a quantitative sense of the arising problems including double parking, longer VMT, causing traffic bottlenecks etc. Understanding the causes of congestion problems help make policy decisions. 3) The proposed framework of using drone delivery to remove road delivery traffic provides practitioners a solution to reduce urban congestion from parcel delivery. The traffic management framework of efficiently assigning schedules and resolving conflicts can serve as a preliminary study to develop operational tools to be applied in practice. 4) The study of the comprehensive assessment of innovative UPD modes including developed framework, identification method, and statistical model can be the basis of future studies.

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