HARVARD Kennedy School

TAUBMAN CENTER
for State and Local Government

Autonomous Delivery Vehicles:
Why You Should Care and What You Should Do

Mark Fagan, Benjamin Gillies, and Edward Guo

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ABOUT THE AUTHORS

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Edward Guo is an undergraduate at Cornell University majoring in Urban and Regional Studies. He is interested in policy issues and implications related to transportation, infrastructure, and sustainable development. He has worked with and studied local government on issues including roadway design, broadband service delivery and flood impact mitigation.

ABOUT THE TAUBMAN CENTER FOR STATE AND LOCAL GOVERNMENT

The mission of the Harvard Kennedy School's Taubman Center for State and Local Government is to support current and future public sector leaders in improving the governance of states, counties, metropolitan regions, and cities through research, teaching, programs, and convenings.

The Taubman Center works to:
- Develop the next generation of state and local government leaders
- Generate big ideas and solutions to state and local government challenges
- Help state and local government implement and scale solutions

The Taubman Center focuses on urban policy issues, including economic development, transportation, education, public infrastructure, land use, social services, public sector technology and data utilization, procurement, and performance management.

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INTRODUCTION

Imagine . . . Imagine ordering your groceries online and having them brought to your door by an autonomous vehicle. Imagine having your pizza dropped off by a robot. Imagine having your prescription shipped across the country in a self-driven semi-trailer, then delivered from the pharmacy to your front step aboard an aerial drone. This is not the future; it is the present.

For urban mobility policymakers this new reality is both exciting and anxiety-provoking. Autonomous delivery vehicles (ADVs) offer the promise of less congestion and greener shipments, critical as the volume of deliveries skyrockets. Simultaneously, ADVs raise concerns about safety and use of road and sidewalk infra-structure. There is also the risk of highly efficient delivers hollowing out brick and mortar retail and dining in communities.

This policy brief provides an overview of the current ADV offerings, their impact on urban mobility, and a path forward for policymakers to tap the benefits and minimize the risks of this new technology.

THE STATE OF THE ART

In Houston, Texas, residents can get their groceries from Kroger delivered via an auton-omous vehicle operated by the AV company Nuro, which brings your order directly to your door. Some of those groceries may have been shipped in from Dallas on an automated long-haul truck, as UPS, FedEx, and JB Hunt Transport Services are all con-ducting pilot projects with self-driven semis running themselves at high speeds for hundreds of miles (with a safety driver in place) between these two Lone Star hubs.[1]

Robots operated by Starship Technologies have completed more than two mil-lion deliveries and are dropping off dinner on four-dozen college campuses and along sidewalks in communities like Modesto, California.[2] Trundling along at five miles per hour, the company's fleet has expanded fourfold since 2019, with other companies like Kiwibot and Grubhub following in their tire treads with their own autonomous sidewalk bots.[3]

Meanwhile, Walmart has partnered with DroneUp to deliver small packages from drones in Farmington, Arkansas. With 4,700 stores stocked with more than 100,000 of the most-purchased items located within ten miles of 90 percent of the US population, Walmart executives believe their business footprint is ideal for drones.[4] Their vision is an online delivery platform serving its customers in as little as 30 minutes.

Experiments like these can be found around the country and are expanding. If you haven't seen them in your neighborhood yet, they are coming.

OPPORTUNITIES AND RISKS

Given the traditional focus on human travel amongst transportation planners and policymakers—whether on foot, by bike, or by bus—it can be easy to forget just how significant the delivery industry is. Yet it is massive: 20.2 billion retail packages are delivered every year, while prepared food delivery has more than tripled since 2017 and doubled between 2019 and 2021 alone.[5] This demand adds up to big revenue opportunities for operators; package and food delivery are $171 billion[6] and $150 billion markets respectively.[7]

Yet despite all this revenue, many elements of the delivery space remain unprofitable. Most food delivery platforms like DoorDash and UberEats, in fact, lose more money than they make.[8] The biggest financial challenge the industry faces is labor—especially in the last mile of service, which accounts for about half of the total shipping cost.[9] Labor is 50–60 percent of the last-mile delivery expense,[10] with drivers costing anywhere from $16 per hour to $100,000 per year.[11] Moreover, labor shortages, which have been present for years and exacerbated by the pandemic, are another headache. FedEx, for example, saw its on-time performance for Express and Ground services sink by ten percentage points (down to 85 percent) due to labor shortages.[12]

Given these challenges, many transportation and tech leaders have come to the conclusion that vehicle autonomy is the way forward for future growth and profitability, and are coming together to put self-driving delivery vehicles on American roads, sidewalks, and in its airspace. With so much money at stake, dozens of existing and startup players backed by billions in capital funding are looking to establish themselves in this industry.

For urban policymakers, these autonomous delivery vehicles represent both an opportunity and a risk. Many cities are grappling with increased congestion resulting from more delivery vehicles. Delivery volumes were already on the rise pre-pandemic, and COVID has accelerated this trend. The congestion results in longer transit times, greater carbon emissions, as well as safety risks. Autonomous delivery vehicles offer the potential for reducing congestion through greater vehicle efficiency by "right-sizing" fleets, trip stacking, and operating for longer hours. They also can be programmed to stop at designated curb locations, eliminating the double or triple parking seen in many cities today.

The use of sidewalk robots or aerial drones removes some vehicles from the roadways, yielding more benefits. Moreover, the expectation is these vehicles will be electric powered, reducing their carbon footprint. Finally, they provide safety benefits by reducing crashes and accidents resulting from human error. In fact, a 2021 Virginia Tech Transportation Institute study estimates the full-scale market penetration of occupantless vehicles would reduce national road fatalities and injuries by between 55 and 62 percent—saving about 34,000 American lives and avoiding four million injuries per year—with most of the reduction coming through the removal of occupants who were simply making a trip to a store for goods that could have been delivered.[13]

On the other hand, the shift to automated delivery vehicles poses several risks. First, the technology must be reliable to ensure that vehicles do not fail on roads or sidewalks due to hardware or software problems, while the safety assurances associated with aerial drones are essential. Second, the vehicles must not interfere with other vehicles, cyclists, and pedestrians using urban infrastructure. Already, cities including New York, Los Angeles,[14] and Toronto[15] have either banned or proposed to ban sidewalk bots out of a concern they will cause issues for pedestrians, especially those using wheelchairs. Third, the vehicles need to be operated as fleets to gain delivery efficiencies so the same number of vehicles is not retained. Fourth, data sharing protocols need to be in place to ensure the availability of information for urban planning while maintaining user and bystander data privacy. Finally, the employment impact on our citizens who currently provide delivery services must be considered.

The use of autonomous delivery vehicles in our urban environment will cover package delivery, groceries and drugstore items, and prepared meals. A range of vehicles will make the deliveries. Some vehicles will be on the road—envision a package delivery truck without a driver. Others will operate on the sidewalk. Yet others will be aerial drones.

The purpose of this policy brief is to enable you to tap the opportunity for your community while mitigating the risk.

AUTONOMOUS DELIVERY VEHICLES ARE COMING

Several factors underpin our confidence that AV delivery is coming and should be a near-term priority. First, broader macro trends support a shift to AV delivery. There has been explosive growth in home delivery. According to data produced by the logistics monitoring company Pitney Bowles, parcel delivery demand was increasing prior to COVID by an average of 10 percent per year. In 2020 as America locked down, delivery

volumes skyrocketed 37 percent. Pitney Bowles forecasts home delivery volumes will continue to increase, from 20.2 billion parcels delivered in 2020 to 32–39 billion sent out in 2026.[16] The growth is across all segments of home delivery, including packages, groceries, and prepared food. Moreover, the expansion of delivery is accompanied by the need for faster delivery. Customer expectations for the time it takes to deliver a package are shrinking from a week or more to same-day or even hours. The delivery time for groceries and drugstore items are also in the one-to-two-hour range. Home delivery of prepared food continues to grow; dark kitchens (restaurants providing home delivery only) is one of the fastest growing segments of prepared food.

The expanding demand for home delivery and the increased pressure for faster delivery comes at a time when providers are facing a labor shortage and rising costs. The trucking industry alone has a shortage of 80,000 drivers in the United States.[17] Meanwhile at the local pizzeria, "there is no store in the country right now with enough delivery drivers," says Dennis Maloney, senior vice president and chief digital officer at Domino's Pizza, which has partnered with Nuro to help fill their truck cabs.[18] In response, companies are increasing wages—in some places going up as much as 50 to 75 percent compared to 2018—but are now finding this is only exacerbating their demand gap, as drivers use the higher paycheck to cut back on the amount of time they are on the road.[19]

This cost environment is pushing the delivery providers to adopt strategies for cost reduction. Improved routing and labor scheduling and associated productivity gains are helping. With fuel accounting for 10 to 25 percent of last-mile expenses,[20] more fuel-efficient vehicles also contribute to savings. However, these changes are at the margin. Eliminating the driver provides a step function improvement in the cost structure of delivery companies. After all, technology advancements in driverless vehicles are fueling the potential for AV delivery. The technology to support full-size package van delivery is progressing in lockstep with great strides made in autonomous passenger vehicles. The developers of sidewalk robots are honing their reliability and safety. Their slow speeds and limited mass reduce safety risks. Drone technology is at a stage where reliable flight is routine, though delivery of parcels to the ground is still a work in progress. While technical challenges remain, there is no shortage of funding for the continued development of AV delivery technology with billion-dollar partnerships leveraged among many of the existing and upstart truck, transport, and tech companies including Ford, Peterbilt, FedEx, UPS, Waymo, and Amazon.

There is one critical hurdle yet to be addressed: the last 100-foot problem. Consumers expect delivery to the door, but many of the technologies currently available provide delivery only to the curb. There is an open question as to whether consumers

will accept curb delivery. Several approaches have been proposed to overcome the 100-foot journey. One concept is a vehicle consisting of dozens of individual compartments containing packages for consumers. The vehicle is parked outside major residential buildings where the resident picks up their package as they enter the building. For buildings with a door person, that individual could be a partial solution by meeting the AV delivery vehicle at the curb and bringing in packages to the lobby or mailroom. Alternatively, several companies are working on robots to provide door delivery. "Digit," developed by Agility Robotics, has the ability to not only walk but also traverse stairs. Ford Motor Company was the first company to purchase Digit prototypes back in 2020, envisioning the lifelike robots stashed in the back of a delivery van and deployed to walk up your steps and drop a package off at your door.[21] Other door delivery robots are also on the drawing board or being tested.

A PEEK INTO THE FUTURE

Autonomous vehicle delivery represents a potential disruptive innovation in the urban mobility environment. The last disruption was the arrival of transportation network companies (TNCs) including Uber and Lyft. For the general public, the TNC represented a better-quality, cost-competitive alternative to existing taxis and transit. The proof of their value proposition was their explosive growth. For many mayors, however, TNCs were a headache. They increased congestion, took away passengers from buses, upended the taxi sector, and raised safety concerns. Nevertheless, in many cities, by the time policymakers tried to establish regulations it was too late. The TNCs were readily able to leverage support from their customer base to prevent significant regulation. Need proof? Next time you are out for a walk, observe the number of TNCs blocking a street in front of a bus stop to pick up or drop off a passenger. Policymakers continue to battle for sensible TNC regulation.

AV delivery vehicle operators could well take a similar path: come in unregulated, prove their worth to customers, and then prevent regulation. They have every incentive to do so since unfettered operations are likely to be less costly than those that are regulated. For example, regulations that restrict curb access to designated pickup and delivery locations add a constraint to the operator, reducing productivity and increasing costs. A similar outcome results from delivery hour restrictions. Sidewalk delivery robots impeding pedestrians, especially those with impairments, must be avoided. Having a bystander hit by a falling package from a drone or lacerated by one of its propellers is certainly not the best path to reelection. Of course, banning AV delivery is not a desired

solution. A world without AV delivery could well be worse. In the absence of these vehicles as described above, congestion, pollution, and safety concerns will abound.

SHAPING YOUR CITY'S FUTURE

As a policymaker, the task is to adopt policies and regulations now that set the right incentives and expectations for the AV delivery industry before operations become entrenched. The "right" answer will vary based on the individual needs of a community. The recipe for designing the right AV delivery policy for your city consists of four ingredients:

1. **Establish a vision for the delivery environment you would like to see in your community.**
   This should be broad based, not restricted to AV delivery. The tasks are:
   • Elaborate the overall city vision, goals, and development trends.
   • Profile the current delivery landscape Including its strengths and limitations.
   • Identify stakeholder goals.
   • Draft a vision of the future delivery environment.
2. **Define the requirements needed to realize the vision.**
   Ask the following questions:
   • What policies require modification and where are new policies necessary?
   • What resources are required to support the new policies?
   • What is the timeframe for change?
3. **Consider how AV delivery can facilitate or restrain the achievement of the vision and design a set of policies that tap the benefits of AV delivery while mitigating its risks.**
   Develop answers to:
   • How can AV delivery facilitate our Vision achievement?
   • What AV delivery policies are necessary enablers?
   • Who are the potential partners in this process?
   • What specific risks—both operational and political—must be mitigated, and how can that be accomplished?

4. **Experiment: Run pilots to test the policies and learn from the pilots to refine and broaden the adoption of the right policies.**
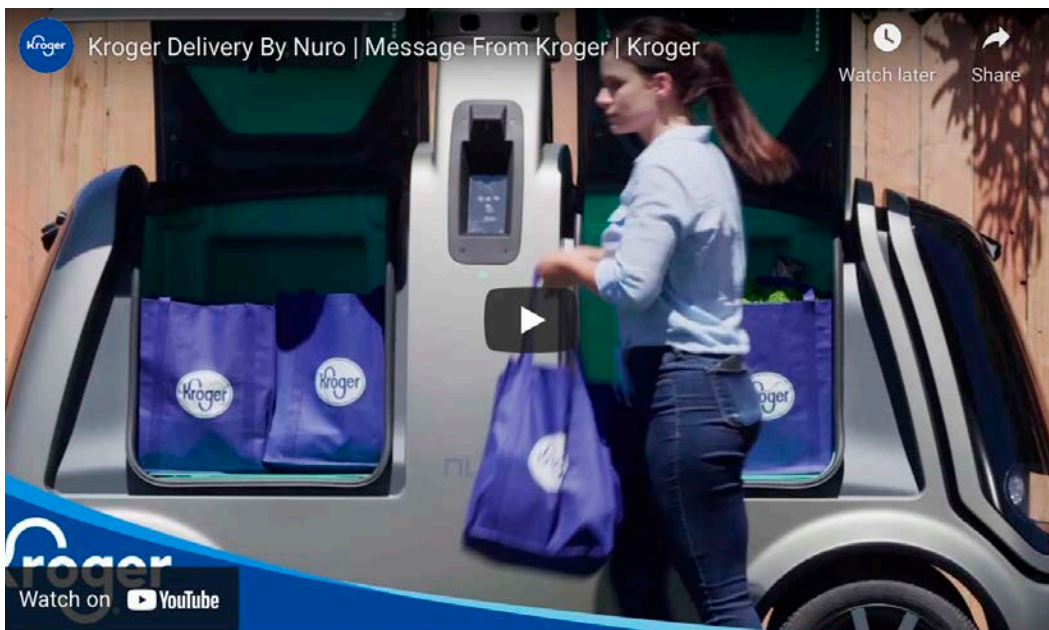   Action items include:
    - Identifying and selecting use cases with high immediacy and impact.
    - Crafting detailed implementation plans and evaluation criteria.
    - Exploring and building local partnerships.
    - Launching!

This action plan will enable you to shape the AV delivery environment to maximize public value.

The Autonomous Vehicle Policy Initiative at Harvard Kennedy School's Taubman Center for State and Local Government can help you prepare for AV delivery. Contact Mark Fagan at: mark_fagan@hks.harvard.edu for more information or visit our website at: https://www.hks.harvard.edu/centers/taubman/programs-research/autonomous-vehicles-policy-initiative

IMAGES

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A food delivery robot crosses a street in Ann Arbor, Mich. on Thursday, Oct. 7, 2021. Robot food delivery is no longer the stuff of science fiction. Hundreds of little robots __ knee-high and able to hold around four large pizzas __ are now navigating college campuses and even some city sidewalks in the U.S., the U.K. and elsewhere. While robots were being tested in limited numbers before the coronavirus hit, the companies building them say pandemic-related labor shortages and a growing preference for contactless

NOTES

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