

Last-Mile Delivery Innovations and Challenges

CTS Transportation Planning and the Economy (P&E)
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General Context

Before and especially during COVID-19

- E-commerce rapid increase
- Dramatic changes in demand patterns
- Supply chain realignments

E-Commerce trends

- April/May online sales up 7% over 2019 holiday peak, 50+% over April/May 2019 (Adobe Analytics)
- Walmart's ecommerce sales increased by 74% in the first quarter of 2020
- Amazon posted \$36.6 billion in sales in the first quarter of 2020, compared to \$29.5 billion in the first quarter of 2019 (24% increase in online sales)

Food/Grocery Delivery

- Instacart order volume saw a 500% growth in April 2020 over April 2019
- Instacart: 150,000 shoppers Pre-COVID and 500,000+ shoppers in April
- 300% growth overall online, food and beverage fastest-growing category in ecommerce

Parcel Delivery - Hazard Pay

- Amazon instituted a base pay increase from \$15 to \$17 per hour for warehouse associates from April to June
- Labor unrest
 - Instacart Walkout
 - Amazon warehouse walkouts

Autonomous (ground) Delivery Robots (ADRs)

- Deliver items to customers
- NO delivery person
- Travel on sidewalks/roads



Starship SADRs

- SADR vs RADR

Tradeoffs: payload, speed, and range



Nuro RADR



Udelv RADR

Starship's Prototype Mothership



Diesel Mercedes-Bens Sprinter Cargo Van, carries up to 8 SADRs

Human driven

Asia: coronavirus lockdown sparks expansion of drones and robot deliveries



ZhenRobotics's RoboPony and JD servicing retailers, hospitals, malls and apartment complexes



Temporary Hospitals in California: ferrying food, supplies, and medical equipment



NURO delivery robots

<https://roboticsandautomationnews.com/2020/04/27/nuro-puts-its-delivery-robot-into-action-against-coronavirus/31956/>

Mayo Clinic, Jacksonville, Fla.: transporting viral tests and supplies



NAVYA minibus

<https://www.govtech.com/fs/automation/Autonomous-Shuttles-Find-Work-in-Fight-Against-Coronavirus.html>

Fast changing landscape...

- Amazon
- Postmates
- FedEx
 - range 8 miles
 - tare 200 lbs,
 - payload 100 lbs, and
 - speed 10 mph



Credits: FedEx <https://thefuturefedex.com/?search=true&spterm=bot> ,
Postmates <https://blog.postmates.com/meet-serve-the-newest-member-of-the-postmates-fleet-e3884825b94c>

Typical SADR Regulations

- Weight limit up to 80 lbs (36kg)
- Speed limit of 10 mph (16kph)
- Follows pedestrian laws
- Insurance policy
- Headlights
- Brakes

Typical RADR Regulations

- Insurance policy (in the millions of USD)
- Operator must have driver's license
- Manual override feature
- Applies to automation levels 4 & 5

Drone Types

- Multicopter vs Fixed-wing
- ICE engine vs Electric

Tradeoffs: cost, performance, flexibility, feasibility for urban applications.



Testbed Exceptions FAA regulations



“With the help of Flytrex and EASE Drones, we are deploying UAVs to limit unnecessary exposure to the coronavirus. We hope other communities will follow.”

Grand Forks, ND, Mayor Michael R. Brown

Vehicle	Tare (kg)	Max. Speed (kph)	Payload (kg)	Range (km)	Approx. Energy consumption (wh/km)
Starship	18	6	18	3	25
Nuro	680	56	110	16	140
Udelv	1890	97	590	97	194
MD4-3000	10	72	5	36	22
Renault EV	1360	160	720	120	205
Dodge RAM	2170	180	1890	695	1016

Some numbers rounded for readability



Ideal Vehicle Fleets* (energy-emissions)

	Low Density	High Density
Depot Close to Service Area **	Drone	Drone/Nuro
Depot Far from Service Area	E-Van	Udelv/E-van

* **Time** constraint results

Ideal Vehicle Fleets* (cost)

	Low Density	High Density
Short delivery time	Conv. Van	Conv. Van
Long delivery time	Mixed** Drone	Nuro/Udelv

* **Time** constrained results

** **Mixed** results depending on dominant constraint

Business to Consumer Last Yard Delivery Types



ONTO THE
PORCH



INTO A MAILBOX



INSIDE THE
HOME OR CAR



INTO A STORAGE
LOCKER

Least Secure ----- Most Secure

Technology not ready at scale to deploy...



“The tech is not necessarily good enough right now that you can do it without having someone watching it”

MATTHEW JOHNSON-ROBERSON,
REFRACTION ROBOTS, CEO AND
COFOUNDER.

“Fundamentally, it’s that the technology is not ready at scale to deploy. We’re trying hard, I promise.”

DAVE FERGUSON, NURO PRESIDENT
AND COFOUNDER

... but it is progressing rapidly.

Figure Sources: <https://www.wired.com/story/delivery-robots-arent-ready-when-needed-most/>

Changing Landscape

- Freight and deliveries perceived as an essential service
- Cities/states willing to experiment with space and road reallocations
- Long-term realignments, “new normal” with more e-commerce and different supply chains

Consolidation of trends

- Ecommerce growth
- Package and service delivery growth
- Automation: deliveries, warehouses, lockers...
- More than one delivery vehicle type

COVID-19 longer-term impacts

- Remote working and brick&mortar shopping
- Labor and health issues
- More investment in contactless technologies
- Cities reallocating road and curb space

Robotaxis, delivery vehicles

Open and ongoing research questions

- Number of deliveries?
- More or less traffic?
- Equity impacts
- How to value and allocate roadway and curb space?

Publications

- Figliozzi M., 2017, Lifecycle Modeling and Assessment of Unmanned Aerial Vehicles (Drones) CO₂e Emissions, Transportation Research Part D, Transport and Environment, Vol. 57, 251-261
- Jennings, D., & Figliozzi, M., 2019, Study of Sidewalk Autonomous Delivery Robots and Their Potential Impacts on Freight Efficiency and Travel. *Transportation Research Record* 2673.
- Chauhan, D., Unnikrishnan, A., Figliozzi M., 2019, Maximum Coverage Facility Location problem with Drones, Transportation Research part C, 2019
- Jennings, D., & Figliozzi, M., 2020, A Study of Road Autonomous Delivery Robots and Their Potential Impacts on Freight Efficiency and Travel. Forthcoming *Transportation Research Record*.
- Figliozzi M., 2020 Carbon Emissions Reductions in Last Mile and Grocery Deliveries Utilizing Air and Ground Autonomous Vehicles, Transportation Research Part D, Transport and Environment.
- Plus reports and papers under review

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QUESTIONS?