Last-Mile Delivery Innovations and Challenges

CTS Transportation Planning and the Economy (P&E) Research Council Webinar and Meeting
October 8, 2020

Prof. Miguel Figlioizzi
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

SADR­s vs RADR­s

Tradeoffs: payload, speed, and range

Figure Sources: https://media.daimler.com/marsMediaSite/ko/en/15274799; www.nuro.ai
Starship’s Prototype Mothership

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

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

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

[Image of NAVYA minibus]

Fast changing landscape...

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

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
<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Tare (kg)</th>
<th>Max. Speed (kph)</th>
<th>Payload (kg)</th>
<th>Range (km)</th>
<th>Approx. Energy consumption (wh/km)</th>
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</thead>
<tbody>
<tr>
<td>Starship</td>
<td>18</td>
<td>6</td>
<td>18</td>
<td>3</td>
<td>25</td>
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<tr>
<td>Nuro</td>
<td>680</td>
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<td>140</td>
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<tr>
<td>Udelv</td>
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<td>97</td>
<td>590</td>
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<td>194</td>
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<td>MD4-3000</td>
<td>10</td>
<td>72</td>
<td>5</td>
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<td>Renault EV</td>
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<td>160</td>
<td>720</td>
<td>120</td>
<td>205</td>
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<tr>
<td>Dodge RAM</td>
<td>2170</td>
<td>180</td>
<td>1890</td>
<td>695</td>
<td>1016</td>
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# Ideal Vehicle Fleets* (energy-emissions)

<table>
<thead>
<tr>
<th></th>
<th>Low Density</th>
<th>High Density</th>
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<tbody>
<tr>
<td>Depot Close to Service Area **</td>
<td>Drone</td>
<td>Drone/Nuro</td>
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<tr>
<td>Depot Far from Service Area</td>
<td>E-Van</td>
<td>Udelv/E-van</td>
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* Time constraint results
# Ideal Vehicle Fleets* (cost)

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<tr>
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<th>Low Density</th>
<th>High Density</th>
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</thead>
<tbody>
<tr>
<td><strong>Short delivery time</strong></td>
<td>Conv. Van</td>
<td>Conv. Van</td>
</tr>
<tr>
<td><strong>Long delivery time</strong></td>
<td>Mixed** Drone</td>
<td>Nuro/Udelv</td>
</tr>
</tbody>
</table>

* 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, REFRACITION 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


- Chauhan, D., Unnikrishnan, A., Figliozzi M., 2019, Maximum Coverage Facility Location problem with Drones, Transportation Research part C, 2019


- Plus reports and papers under review
Acknowledgments

Dylan Jennings, student research TTP Lab.

Research funded by FMRI (Freight Modeling Research Institute) University Transportation Center
QUESTIONS?