A STUDY OF ROAD AUTONOMOUS DELIVERY ROBOTS AND THEIR POTENTIAL IMPACTS ON FREIGHT EFFICIENCY AND TRAVEL

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Problem Context:

- E-commerce purchases increase by 16% each year in the United States
- Low efficiency of last-mile of deliveries

Figure Source: https://www.augment.com/blog/evolution-ecommerce-last-decade/
Solution: Road Autonomous Delivery Robots (RADRs)

- Deliver items to customers
- NO delivery person
- Travels on roads
- Long range
- Can make multiple deliveries

Nuro RADR

Figure Source: https://www.wired.com/story/nuro-grocery-delivery-robot/
Contents of Our Paper

Capabilities of existing RADRs
Regulation and Legislation
Time/cost savings comparison
Limited to United States, up to June 2019

AutoX RADR

Figure Source: https://www.businessfleet.com/323140/were-learning-very-quickly-using-autonomous-vehicles-for-grocery-delivery
Compare with SADR and Standard Vans

- SADR “mothership” previously researched
- RADR now compared with motherships and standard delivery vans

Mercedes Benz Mothership

Figure Source: https://www.wired.co.uk/article/mercedes-starship-drones-delivery-van
What are the capabilities of RADRs?

- Travel up to 560 miles (901km)
- Speed up to 80 mph (129kph)
- Carry up to 1300 lbs (590kg)
- Deliver to up to 32 customers

Figure Source:
What places have regulations?

Legend:
- Law
- Pending
- None
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
Analysis Methodology

1. Assumptions
2. Distance per delivery
3. Time per delivery
4. Cost per delivery
5. Distance, Time, & Cost for different assumptions
6. Compare motherships, RADRs, and standard
Assumptions: RADR Van

- Autonomously driven
- uDelv RADR
- Up to 32 deliveries
- 3 to 15 minutes per delivery

Figure Source: https://www.cnet.com/roadshow/news/udelv-announces-second-generation-newton-autonomous-delivery-van-ces-2019/
Assumptions: Mothership

- Combine Standard Van with SADR
- Human driver
- Up to 8 SADR
- 3 to 15 minutes per delivery

Mercedes Benz Mothership

Figure Source: https://www.wired.co.uk/article/mercedes-starship-drones-delivery-van
Assumptions: Standard Van

- Visits 1 customer & delivers 1 parcel at a time
- Human delivery person
- Delivers to maximum customers in 10 hr shift
- Same service area as Mothership & RADR Vans
- 3 to 15 minutes per delivery
Assumptions: SADR

- Starship Technologies SADR
- 4 mile (6km) max travel distance
- 4 mph (6kph) max speed
- Delivers up to 6 parcels

Source: https://www.roboticsresearch.ch/articles/14245/starship-technologies-commercial-rollout-of-autonomous-delivery
Comparison Methodology

- Set all variables to “default” values
- Select time per delivery, size of service area, or distance to service area to vary
- Vary selected variable over reasonable range
- Observe which delivery mode is ideal considering distance, time, or cost per delivery
Results Graphs

- **Vary:**
  - Time
  - Service Area
  - Distance to SA

- **Plot:**
  - Distance to deliver
  - Time to deliver
  - Cost to deliver
Vary time per delivery

Delivery distance per customer (mi)

- RADR Van
- Standard Van
- Mothership

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t (min)
Vary time per delivery

Time spent delivering per delivery (hr)

- RADR Van
- Standard Van
- Mothership
Vary time per delivery

Cost per delivery ($)

- RADR Van
- Standard Van
- Mothership

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Special Case: distance to SA = 0

- Assume mothership not needed
- SADRs deliver directly from depot
- VMT = 0 for SADR
- Time van on road = 0 for SADR
- Cost fixed at $2 per delivery for SADR
- SADR clear ‘winner’ when mothership absent
In Conclusion:

- Possible time & cost savings using RADRs
- Depends on many variables
- Best to analyze for your area or business
- Our case study showed RADRs, Motherships, and Standard Vans all good in different areas: cost, VMT, & time
Related papers


Acknowledgment

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QUESTIONS?