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

Dylan Jennings & Dr. Miguel Figliozzi

Portland State UNIVERSITY

Maseeh College of Engineering and Computer Science
PORTLAND STATE UNIVERSITY

TTP Lab

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)

Nuro RADR

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

Figure Source: https://www.wired.com/story/nuro-grocery-delivery-robot/

Contents of Our Paper

AutoX RADR

Capabilities of existing RADRs

Regulation and Legislation

Time/cost savings comparison

Limited to United States, up to June 2019

Figure Source: https://www.businessfleet.com/323140/were-learning-very-quickly-using-autonomous-vehicles-for-grocery-delivery

Compare with SADR and Standard Vans

Mercedes Benz Mothership

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

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

What are the capabilities of RADRs?

uDelv RADR

Travel up to 560 miles (901km)

Speed up to 80 mph (129kph)

Carry up to 1300 lbs (590kg)

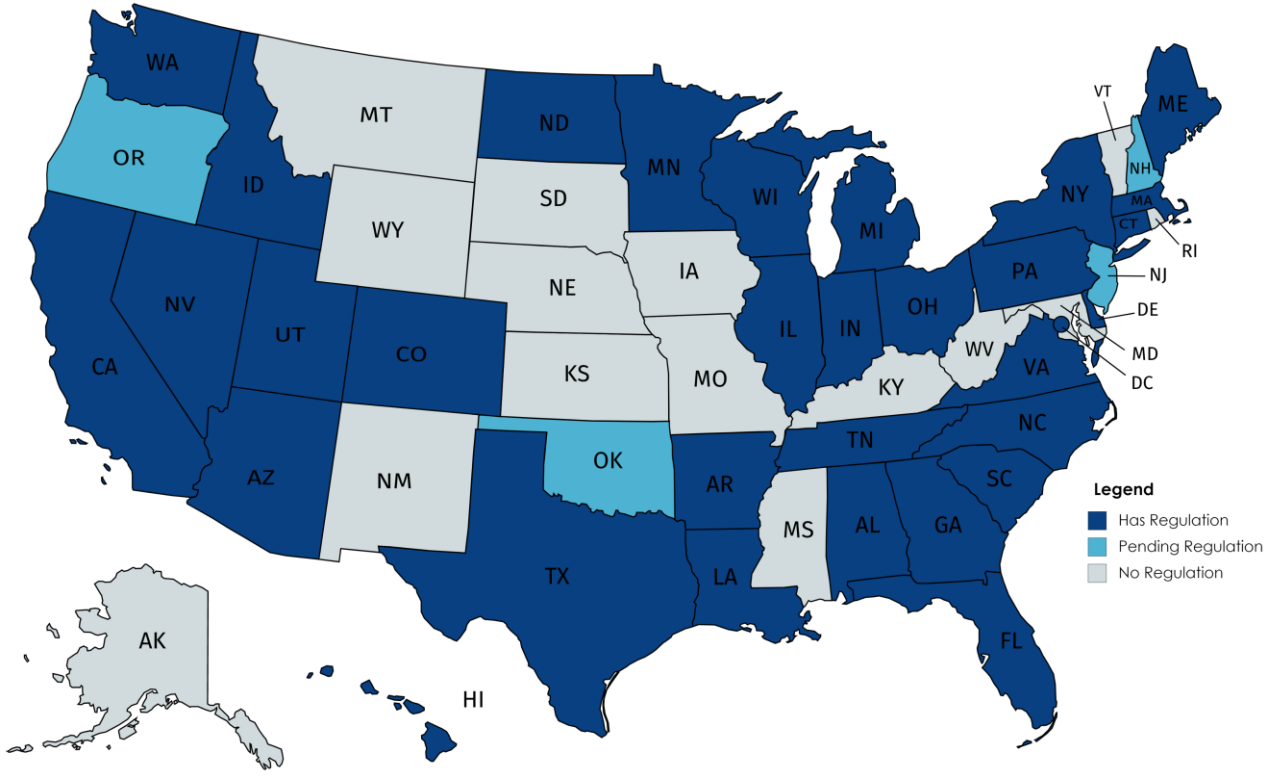
Deliver to up to 32 customers

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

What places have regulations?

Legend:

- Law
- Pending
- None



Created with: https://mapchart.net/usa.html

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

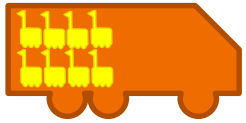
Assumptions: RADR Van

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

uDelv RADR

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

Assumptions: Mothership

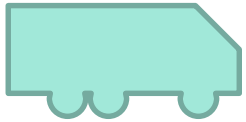


- Combine Standard Van with SADRs
- Human driver
- Up to 8 SADRs
- 3 to 15 minutes per delivery

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

Starship SADR

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

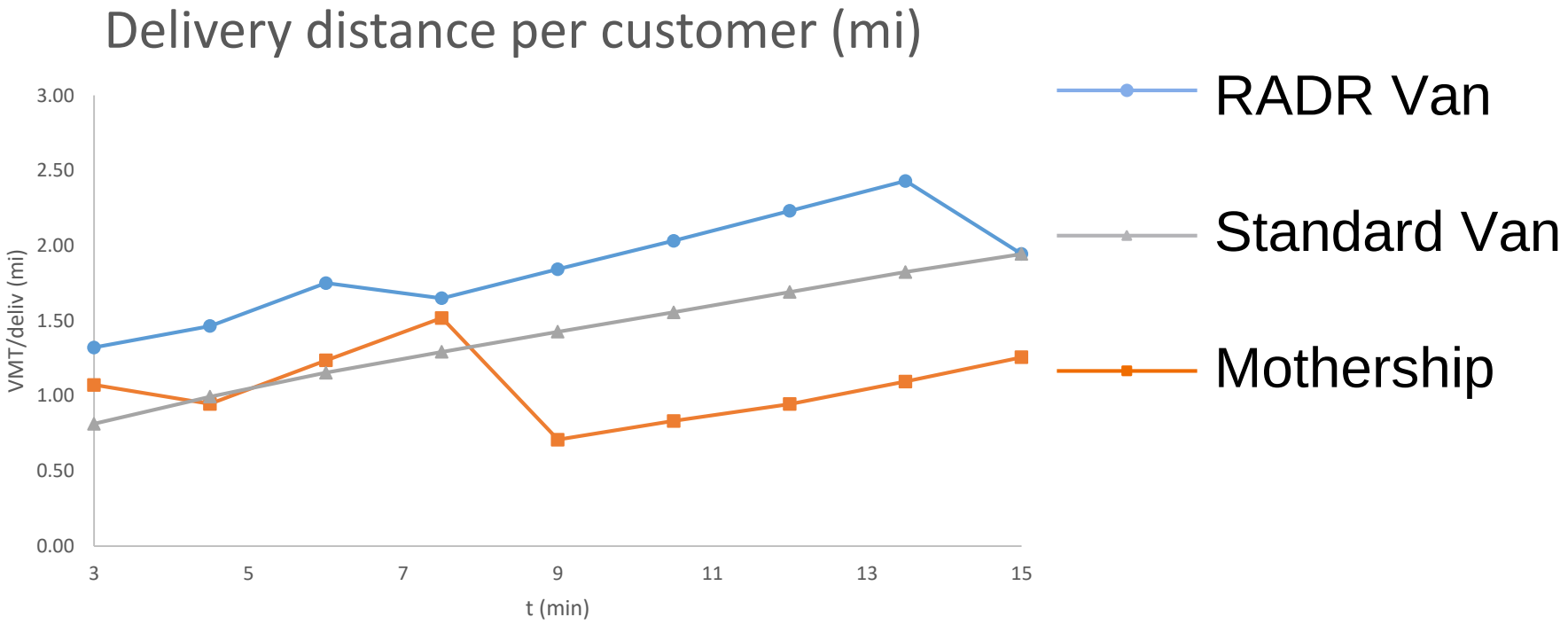
Comparison Methodology

- 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

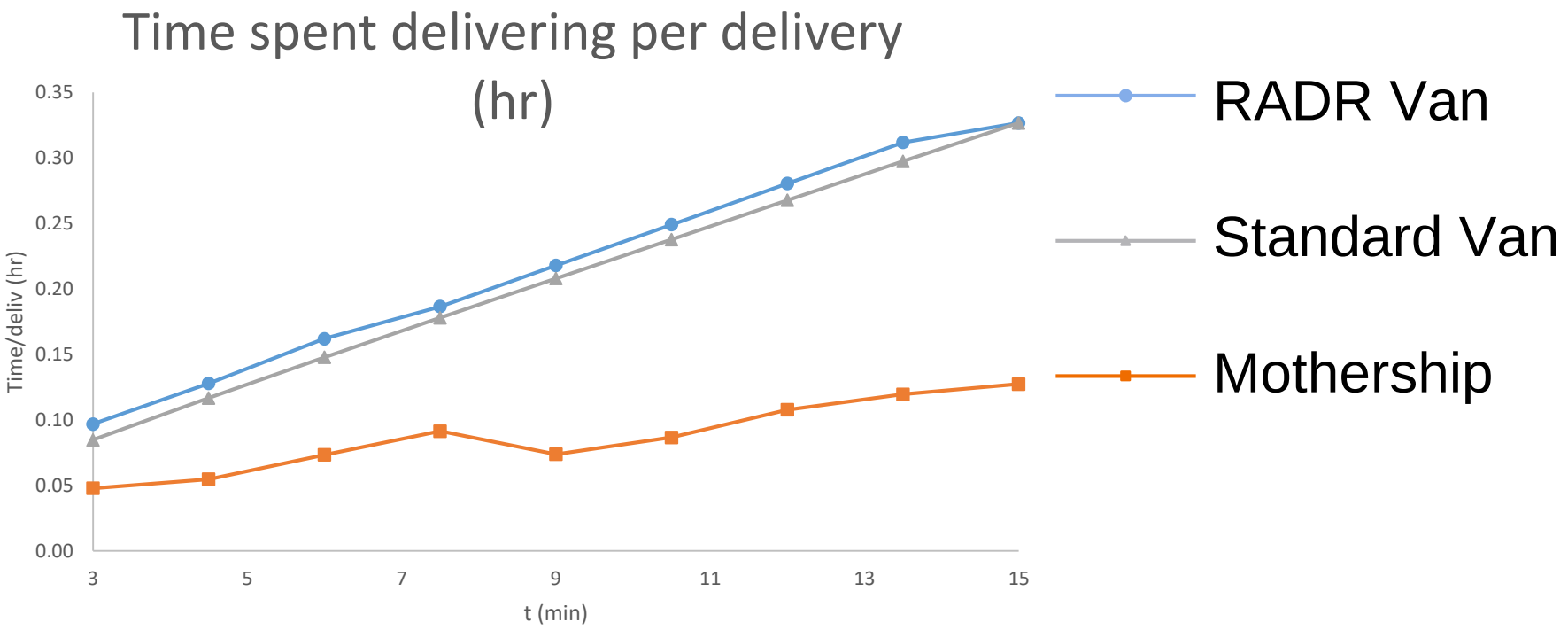
Results Graphs

- Vary:
  - Time
  - Service Area
  - Distance to SA
- Plot:
  - Distance to deliver
  - Time to deliver
  - Cost to deliver

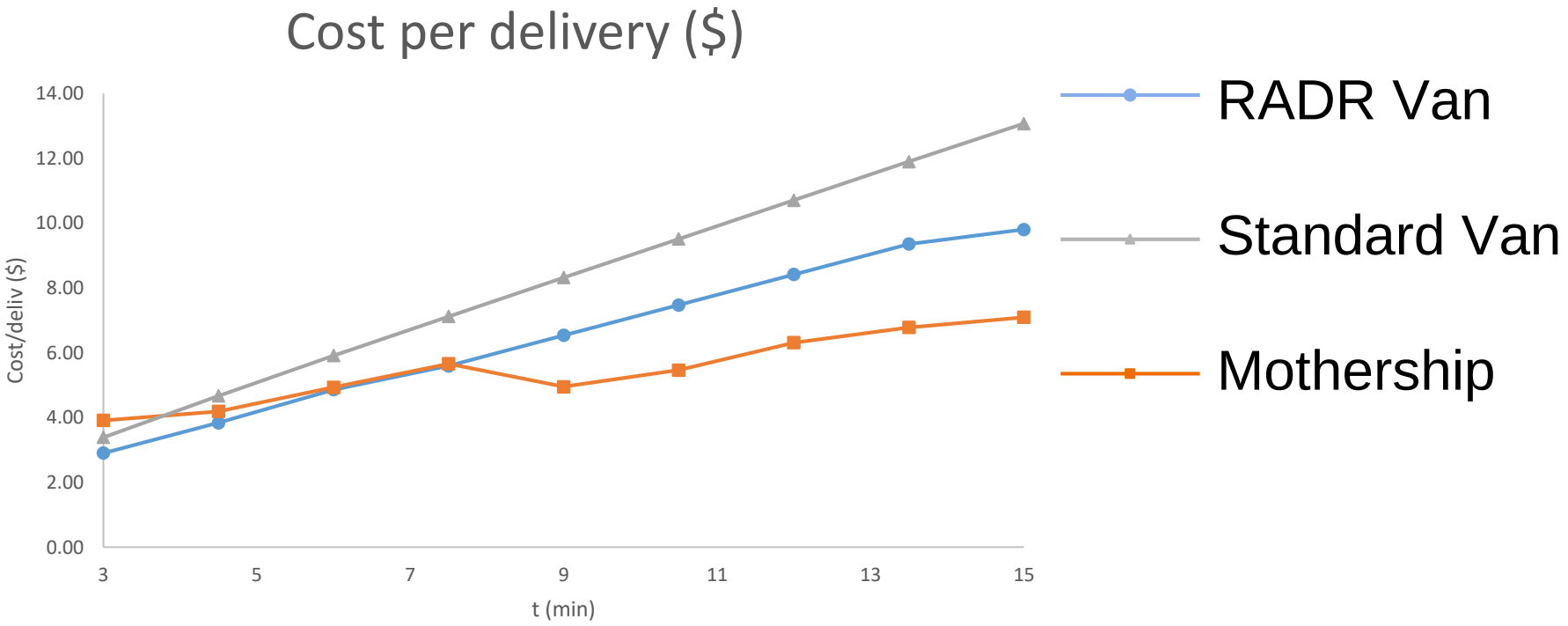
Vary time per delivery



Vary time per delivery



Vary time per delivery



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

Jennings, D. and Figliozzi, M. (2019). Study of Sidewalk Autonomous Delivery Robots and Their Potential Impacts on Freight Efficiency and Travel. *Transportation Research Record:* Journal of the Transportation Research Board, Vol. 2673(6) 317–326.

Jennings, D. Figliozzi, M. . Study of Road Autonomous Delivery Robots and Their Potential Impacts on Freight Efficiency and Travel. To be presented at Transportation Research Board Annual Meeting, Washington DC. USA, January 2020. Paper under review.

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QUESTIONS?