Last mile logistics innovations:
modelling their traffic, energy and environmental impacts

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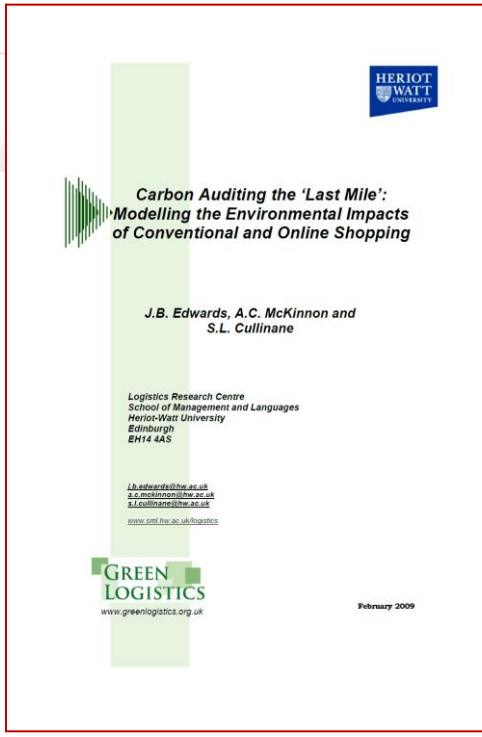
4th International Transport Energy Modelling workshop (iTEM4)

International Institute of Applied Systems Analysis (IIASA)

Vienna

31 October 2018

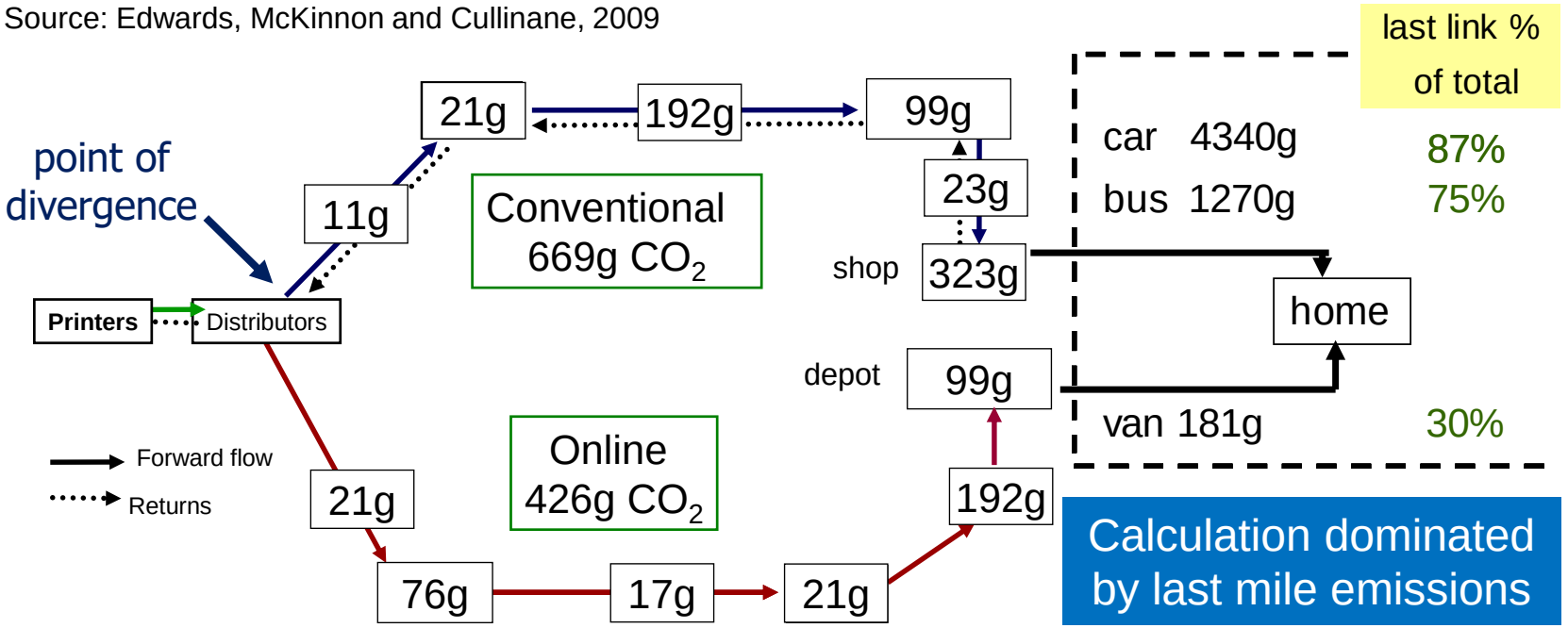


http://www.alanmckinnon.co.uk/story_layout.html?IDX=576&

Comparative Carbon Auditing:

Online and Conventional Retail Supply Chains for Books

Source: Edwards, McKinnon and Cullinane, 2009



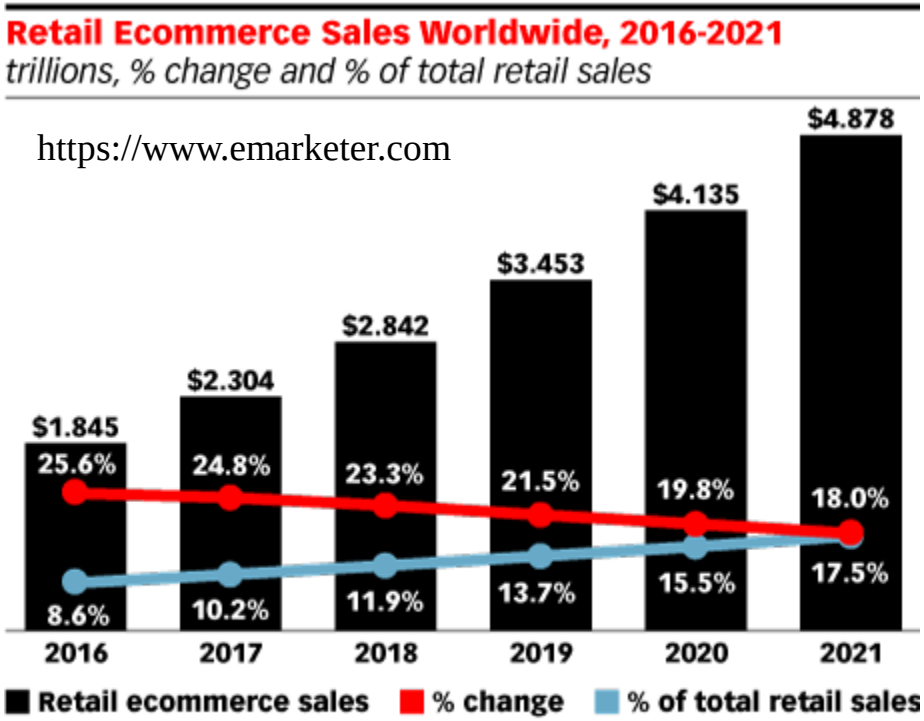
CO_2 advantage of online retailing + home delivery:

Over shopping by car :	*Over shopping by bus*
Supply chain: 8.3 x	*Supply chain 2.8 x*
Last mile: 24 x	*Last mile: 8 x*

Any environmental advantage conditional upon:

vehicle load factors	% of failed deliveries
level of product returns	energy efficiency of warehouses and shops
structure of the supply chain	personal travel behaviour

Transformation of Urban Retail Supply Chains: *effect on carbon intensity of last mile logistics*



logistical challenges of online retailing

- volume growth
- Shortening lead times
- delivery fragmentation
- cost pressures
- environmental impact

Mainly impacting on the last mile

The Possible Impact of 3D Printing and Drones on Last-Mile Logistics: An Exploratory Study

ALAN C. MCKINNON

https://bit.ly/2AT8Kj2

Crowdshipping

A communal approach to reducing urban traffic levels?

https://bit.ly/2JrCj01

Other last mile logistics innovations – *energy / emission impacts?*

unattended delivery

decouping delivery and urban portering

parcel carrier collaboration

ups dpd Hermes Deutsche Post DHL

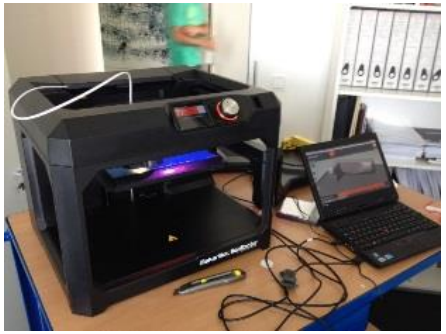
Uberization of urban freight

delivery robots (droids)

instant replenishment

self-ordering devices

consumer-based 3D printing



Parcel delivery by drone

China - Alibaba

Switzerland

UK - Amazon

Australia – Google / Dominos Pizza

US – Seven Eleven

France - DPD

Impact of Drone Delivery on Urban Traffic Levels

DHL Trend Radar report(2016) '*by potentially reducing the amount of vehicle movements, UAVs can provide traffic congestion relief to densely populated cities*'

Number of drones required to cut total urban traffic by 1% in the UK

163.4 billion vehicle kms (2014) by all vehicle classes

1% = 1.63 billion vehicle-kms

drone : van substitution ratio 15:1	drone : van substitution ratio 10:1
average annual kms per van: 13,700	average annual kms per van: 27,400
1.8 million drones	600,000 drones

Drones may also replace cars making shopping trips, collecting /delivering meals etc

SESAR study - no. of drones required to meet current delivery market potential in UK: 2000

https://bit.ly/2rA3ONy

negligible effect on urban traffic congestion

http://www.alanmckinnon.co.uk/blog/?p=9

Recent Literature on Energy and Environmental Impacts of Parcel Delivery Drones

The Energy Implications of Drones for Package Delivery

A Geographic Information System Comparison

https://bit.ly/2SCwr8g

Express delivery: use drones not trucks to cut carbon emissions, experts say

Research shows drones can deliver certain items faster and with less environmental impact than trucks - but there are drawbacks

https://bit.ly/2nXIBe7

Drone package deliveries may reduce emissions and save energy

https://greennews.ie/drone-delivery-reduce-emissions-save-energy/

Is Drone Delivery Good for the Environment?

Reducing the need for trucking by delivering some packages with electric drones could save fuel, and potentially carbon emissions. But how much?

https://bit.ly/2OjZ9Y0

Drone Delivery, If Done Right, Could Cut Emissions

To make drone package delivery green, look at drone size, electricity source, and warehouses, researchers say

By **Prachi Patel**

https://bit.ly/2C6eiLc

nature COMMUNICATIONS

ARTICLE

DOI: 10.1038/s41467-017-02411-5 OPEN

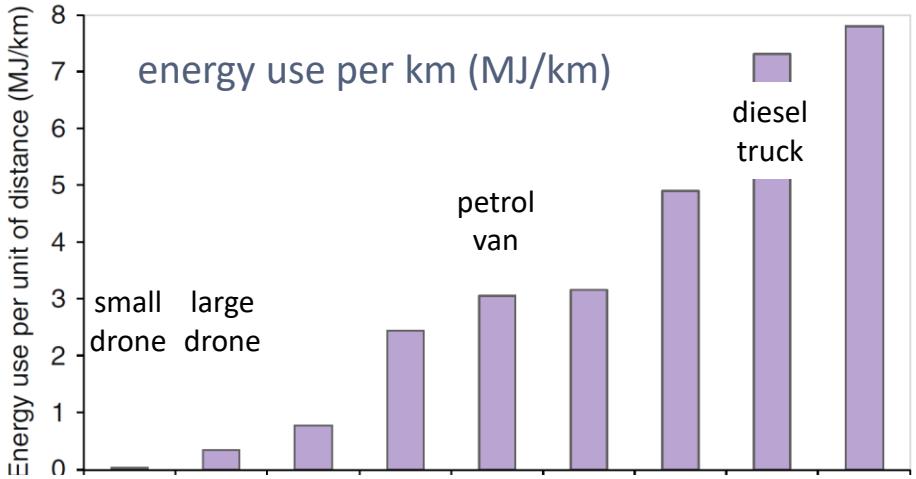
Energy use and life cycle greenhouse gas emissions of drones for commercial package delivery

Joshuah K. Stolaroff[1], Constantine Samaras[2], Emma R. O'Neill[3], Alia Lubers[4], Alexandra S. Mitchell[3] & Daniel Ceperley[3,5]

https://www.nature.com/articles/s41467-017-02411-5

Comparison of energy use and CO_2 emissions: *drone vs ground delivery*

Based on Stolaroff et al (2018)

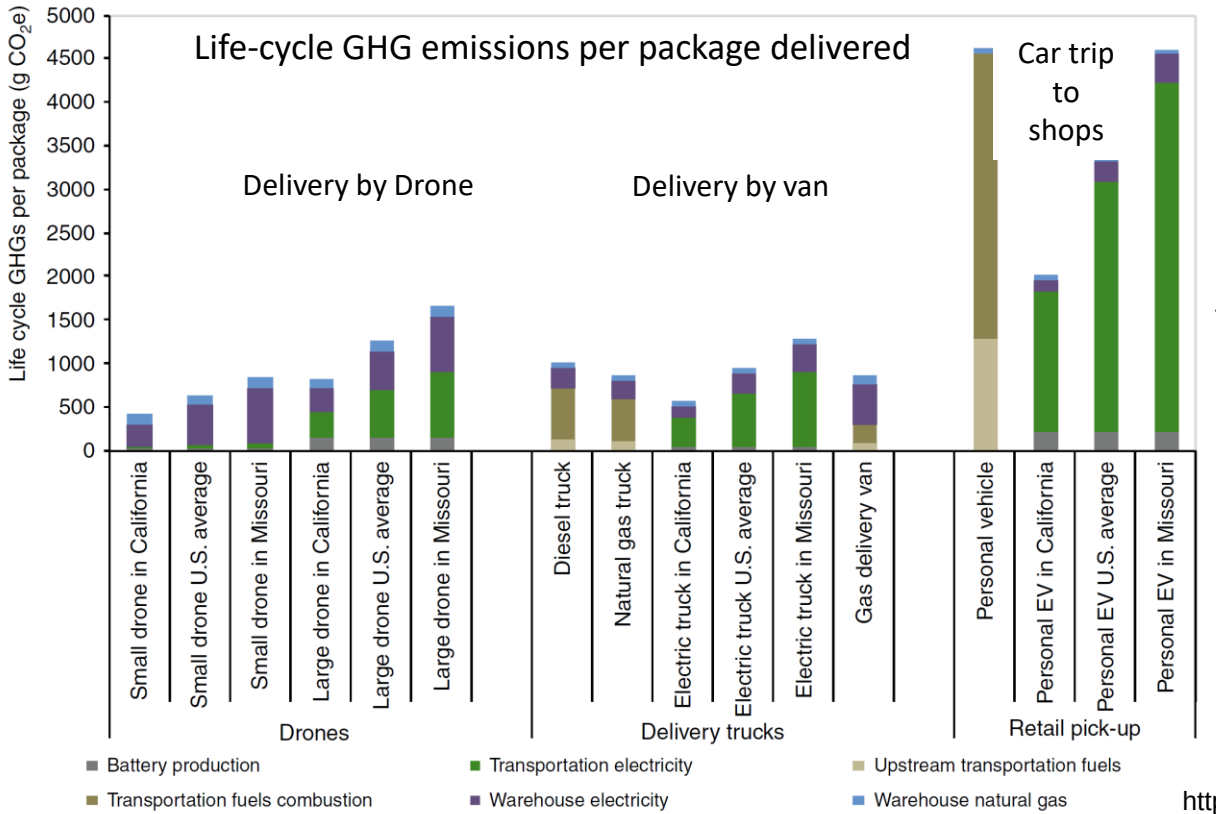


drone delivery range

relative load factors
packages per km based on UPS data

drone-van substitution rate

no electric van option



Battery production

Transport fuel consumption

Transport electricity

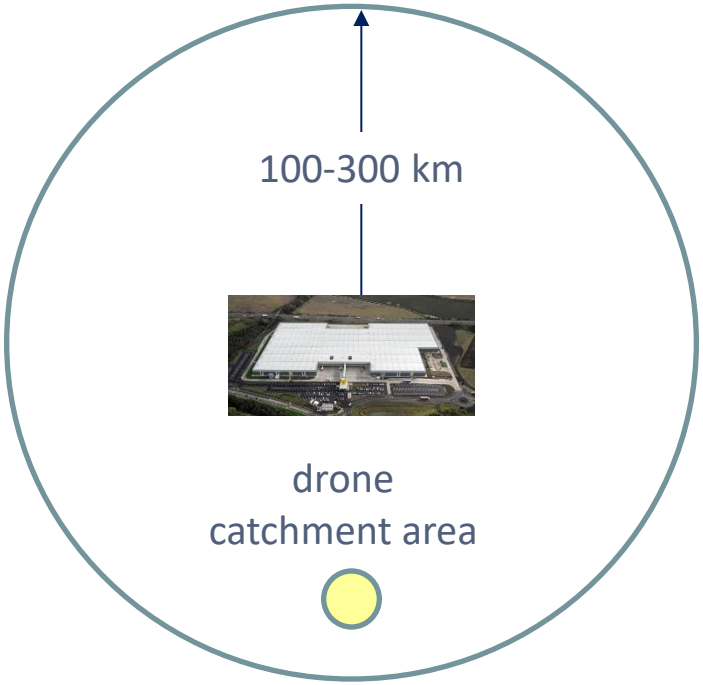
Upstream transport fuels

Warehouse electricity

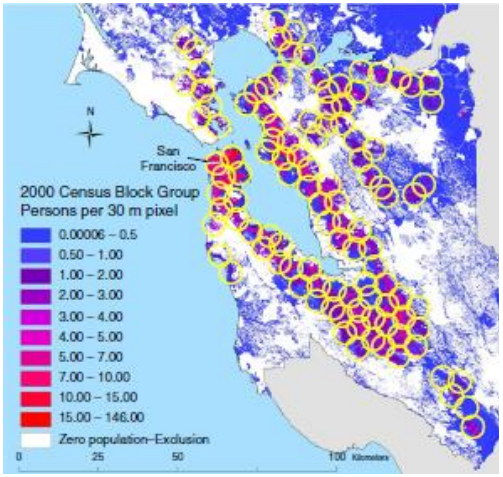
Warehouse natural gas

https://www.nature.com/articles/s41467-017-02411-5

Limited drone catchment area requires extra tier of warehousing



Need '*dozens of new local warehouses*' within area served by a regional distribution centre



112 local drone delivery warehouses in Bay Area

Stolaroff et al (2018)

Critical logistical trade-off: *product diversity versus speed of delivery*

cannot replicate huge product range at local level

restrict drone delivery to small range of 'fast movers'

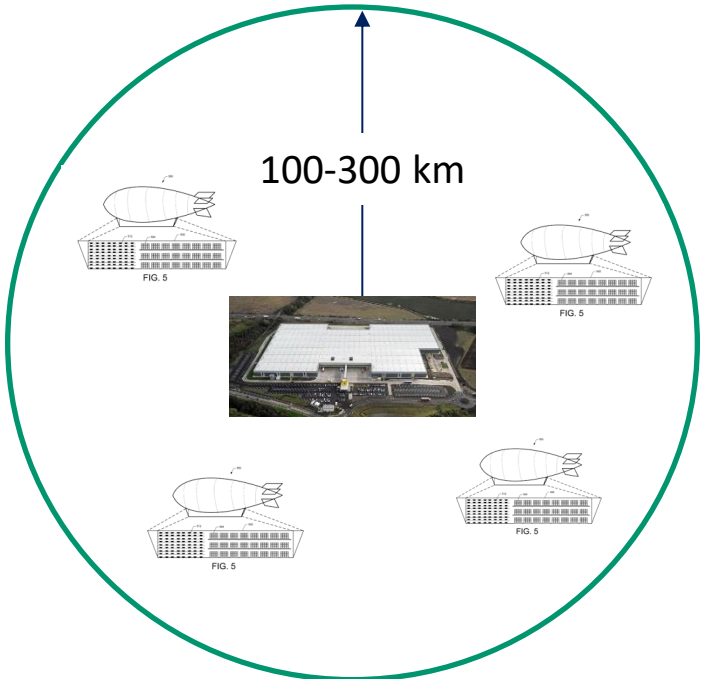
use predictive analytics to pre-position these products

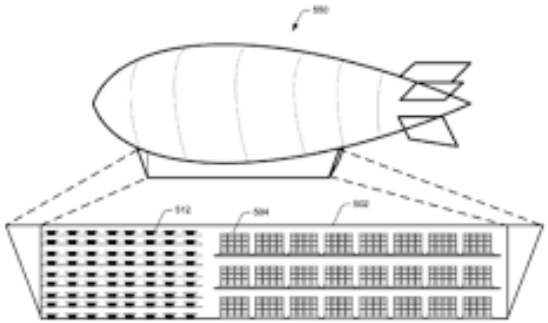
inventory dispersal + local depot network inflates costs

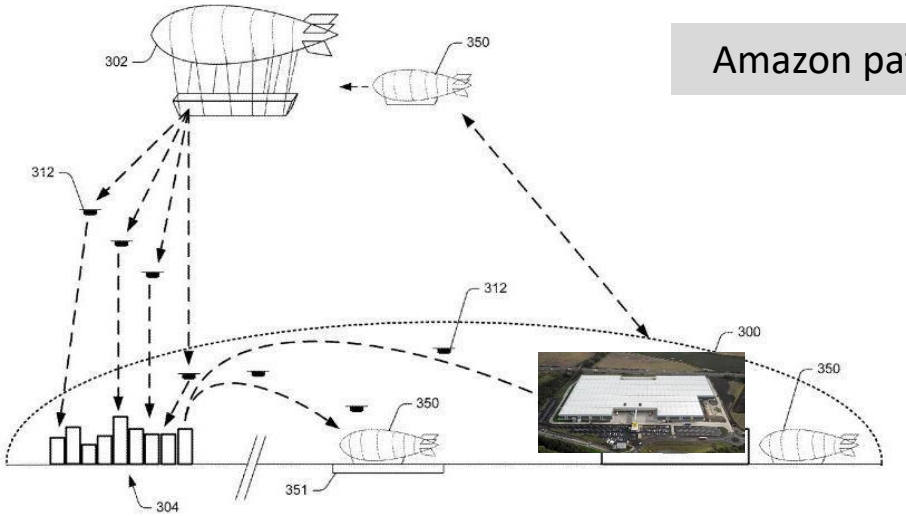
Sophisticated energy and emissions modelling but underlying business model is seriously flawed

Extending the Drone Delivery Range: *the 'Flying Warehouse'*

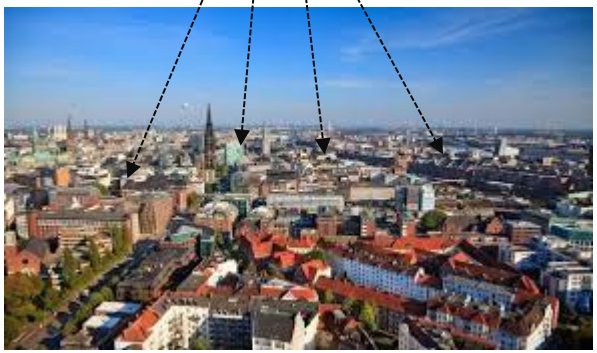
Aerial Fulfilment Centre (AFC)







Amazon patent



45,000 feet

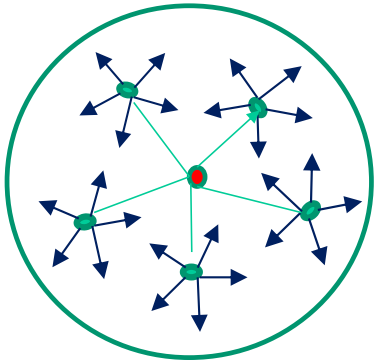
Extending the Drone Delivery Range: *the Drone Truck*

Source: McKinsey, 2016

Overarching product categories		Increasing drop denisity/decreasing cost: Rural areas with low to average density[2]	Urban areas with average density[3]	Urban areas with high density[4]
X2C	Regular Parcel[1]	DRONES	AGV's WITH LOCKERS	
	High reliability, e.g., time window			
	Same Day			
	Instant	FULFILLMENT LIKELY NOT POSSIBLE AT ECONOMICAL COST LEVELS		BIKE COURIERS OR DROIDS
B2B		TODAY'S DELIVERY MODEL		

ref. McKinsey&Company, 2016

1. Between D+1 and D+4 2. Below 50,000 inhabitants 3. 50,000 – 1million inhabitants 4. Above 1 million inhabitants



https://mck.co/2n4sABU

Energy and emission calculation:

- combining drone analysis with variant of the *vehicle routeing and scheduling problem*
- need to model optimal points in the trip at which drones leave and return

Crowd Sourcing of Parcel Deliveries: *Crowdshipping*

zipments

PiggyBee

Piggy Baggy

deliv

nimber

taskrabbit

ROADIE

PostRope

Definition: *'enlisting people who are already travelling from points A to B to take a package along with them, making a stop along the way to drop it off'* (US Postal Service 2014)

- exploiting new spirit of collaboration in the share economy
- commercialisation of social networking

redefining interface between passenger and freight transport

Possible benefits:

- elimination of freight trips
- filling unused space in passenger vehicles
- lower traffic levels, fuel consumption, emissions and congestion

Impact of Crowdshipping on Urban Traffic Levels

1. Degree of spatial and temporal matching between personal travel and freight movement:

Probability of matching = f (number of crowdshippers and receivers)

Initially low probability → longer detours limited reduction in traffic levels

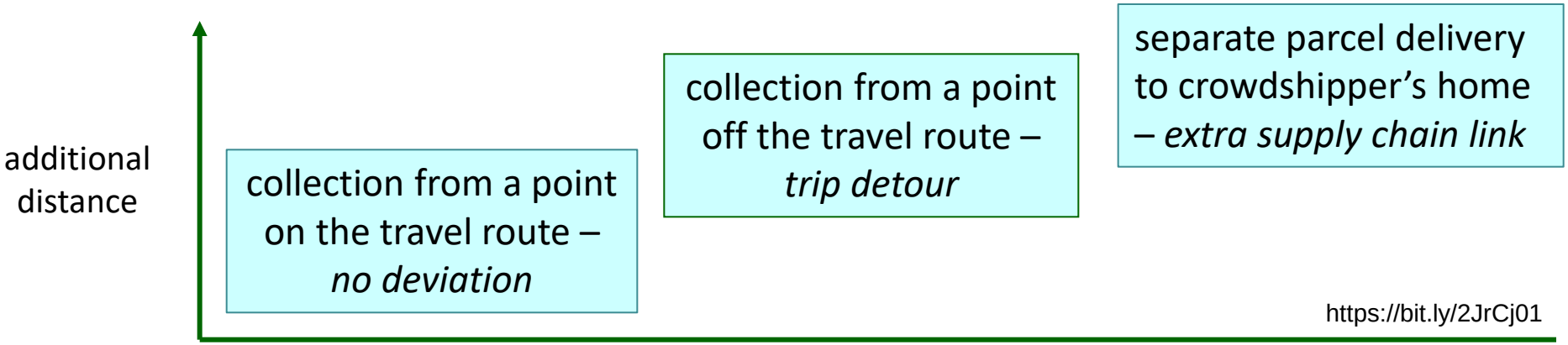
Case study: crowdshipping delivery of library books in Finnish town saved 1.6 vkms per trip

Simulation modelling: complementing optimised dynamic routing of delivery vehicles with '*ad hoc*' drivers in 3 geographical settings – cut delivery costs by between 19% and 37%

Arlsan et al (2016)*'Crowdsourced Delivery: A Dynamic Pickup and Delivery Problem with Ad-hoc Drivers'*
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2726731

2. Integration of crowdshipping into urban supply networks:

Where do crowdshippers obtain the consignments?



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Environmental Impact of Crowdshipping / Crowd Logistics

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Shipping outside the box. Environmental impact and stakeholder analysis of a crowd logistics platform in Belgium

Heleen Buldeo Rai*, Sara Verlinde, Cathy Macharis

Vrije Universiteit Brussel, Research Group MOBI, Pleinlaan 2, 1050 Brussels, Belgium

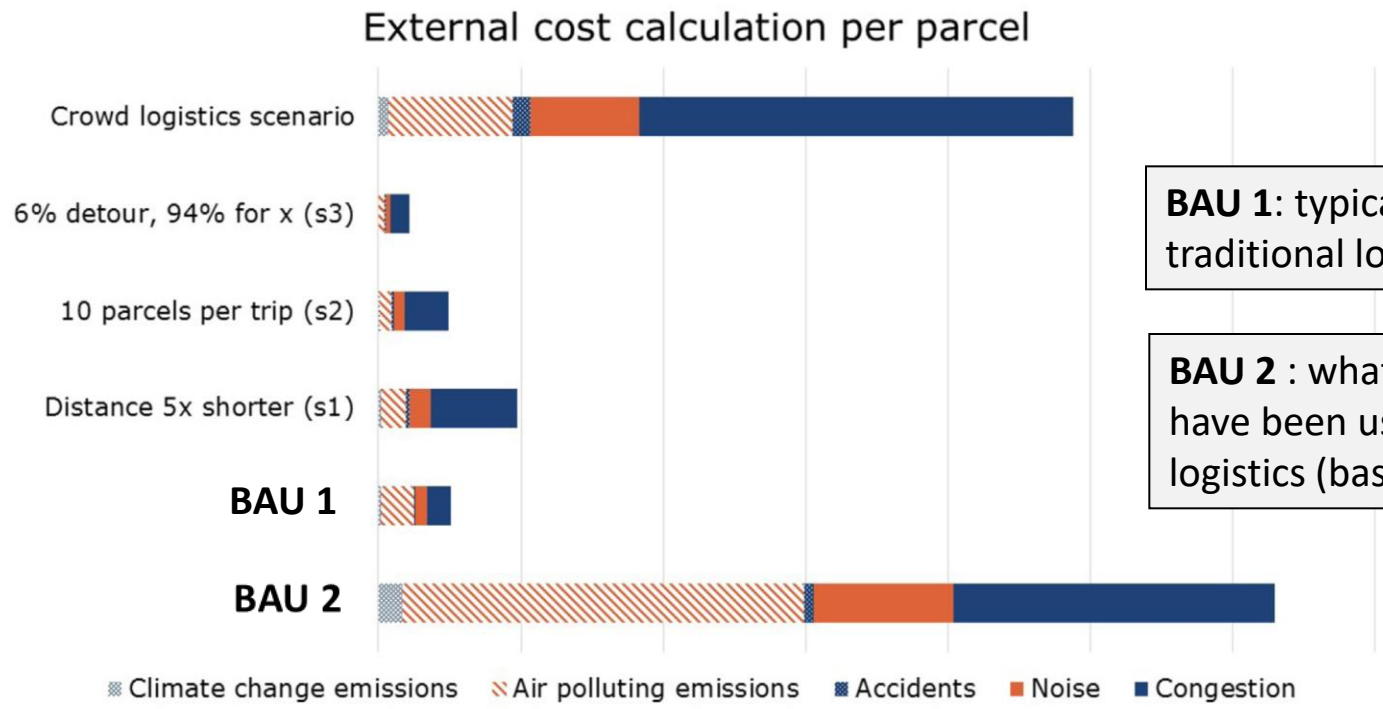
Data base from crowd logistics platform:

2000 trips / 31% survey response

52.5% of trips solely made for parcel delivery

15% of deliveries made on existing trip

32.5% of deliveries on detour > 15 mins



BAU 1: typical delivery route of traditional logistics provider

BAU 2 : what delivery method would have been used in absence of crowd logistics (based on survey responses)

Significant emission reductions relative to BAU 2 scenario but **higher than conventional delivery operations** (BAU 1)

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