Chaire LOGISTICS CITY

Université Gustave Eiffel

Autonomous vehicles' potential for e-commerce deliveries

Heleen Buldeo Rai

Logistics City Chair
Univ Gustave Eiffel

Presentation of the Logistics City Chair

Composition of the Chair

Laetitia Dablanc
Director of the Chair

Heleen Buldeo Rai
Postdoctoral researcher since 2020
Theme 2, booklet 2

Matthieu Schorung
Postdoctoral researcher since 2021
Theme 1, booklet 3

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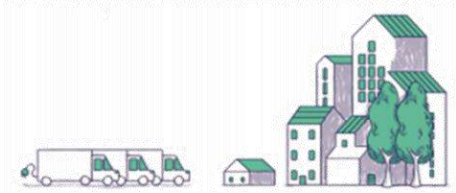
sogaris
La logistique urbaine du Grand Paris

POSTE IMMO

Région îledeFrance

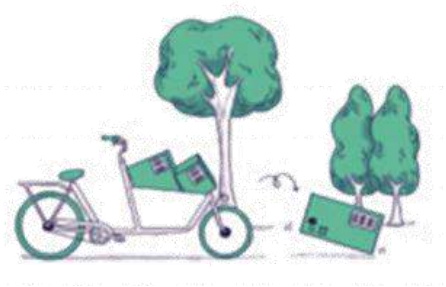
Scientific programme



Theme 1: Urban logistics real estate, new economic models for metropolitan logistics real estate, strategies for the implementation of logistics buildings in large metropolises

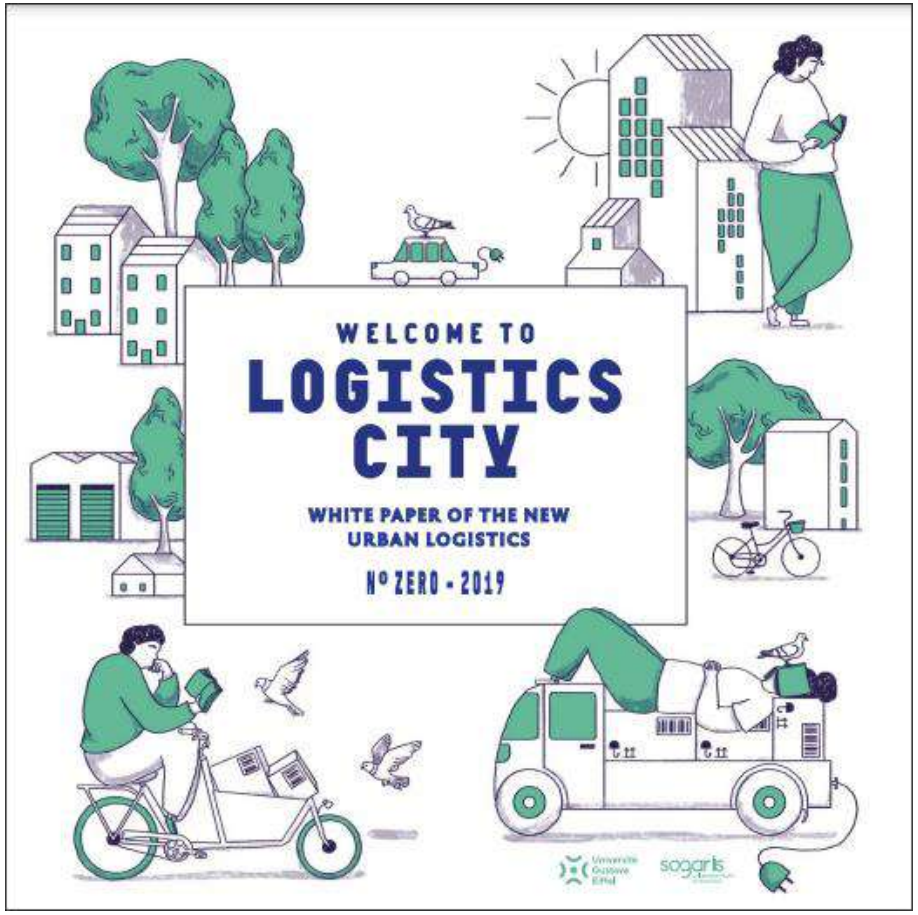
Theme 1.1: **Logistics sprawl and urban logistics**: analysis of territorial dynamics linked to the evolution of the location of logistics activities, at the "macro" level

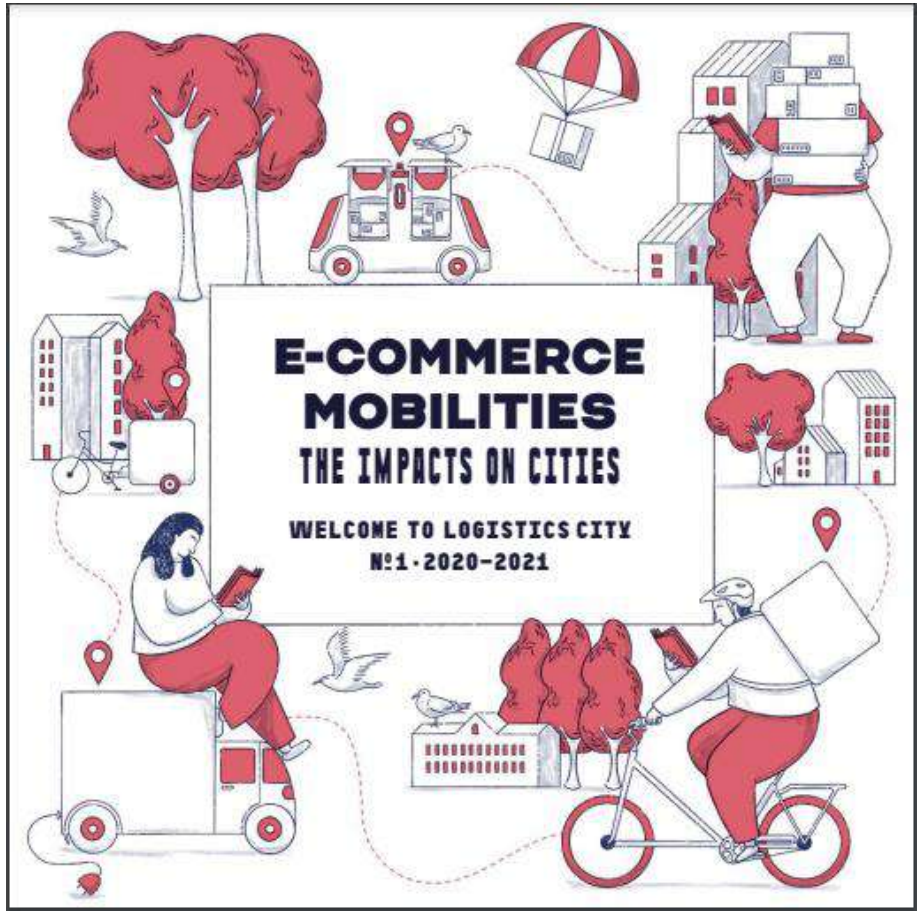
Theme 1.2: **Urban logistics planning**: analysis of public policies, the history of the production of the first buildings, the economic paradox of urban logistics and regulatory obstacles, at the "micro" level



Theme 2: Trends and new practices in consumption, production and distribution impacting on urban logistics and warehousing of the future, in a prospective vision

Booklets “Welcome to Logistics City”

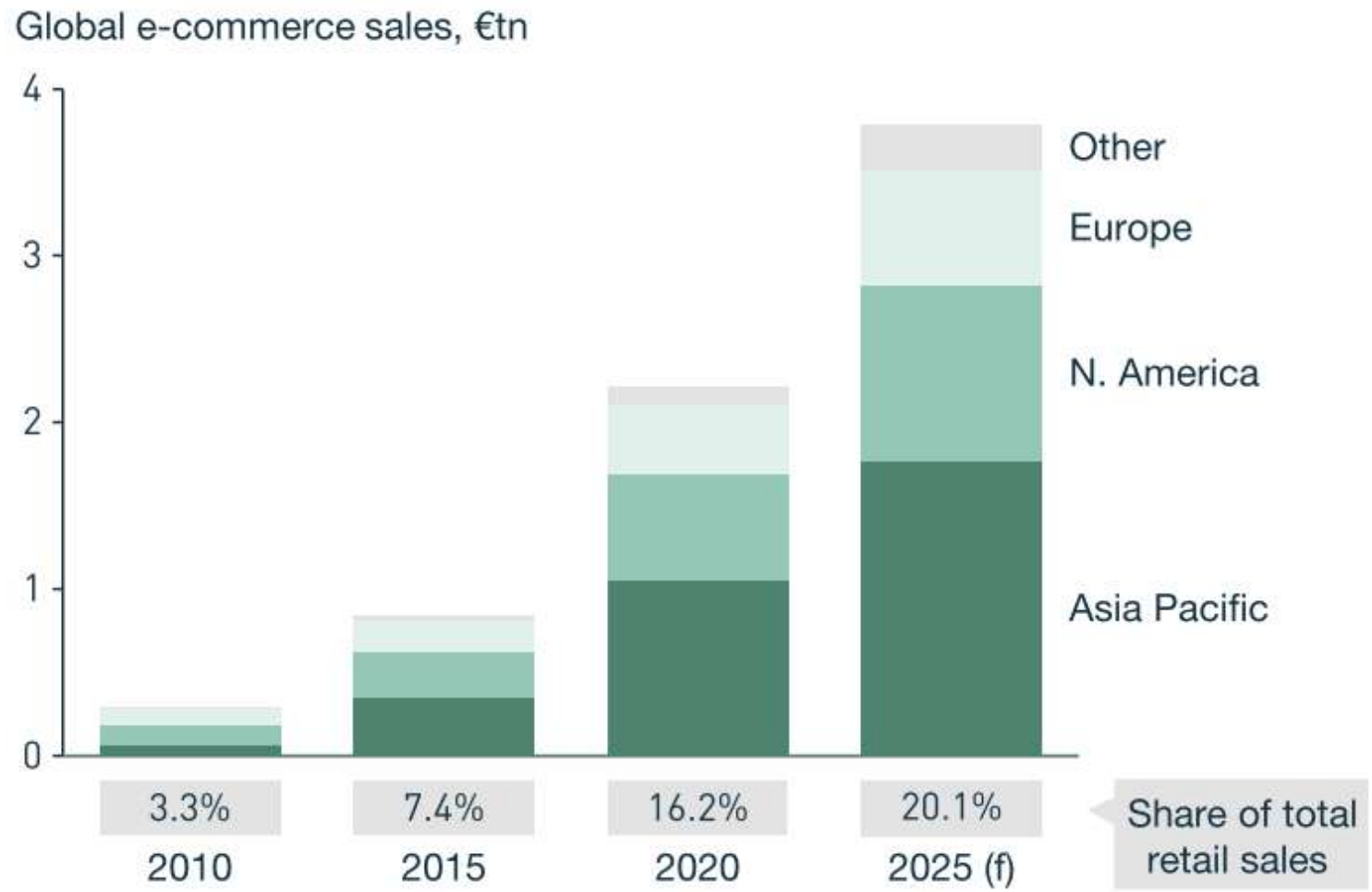




E-commerce mobilities observatory

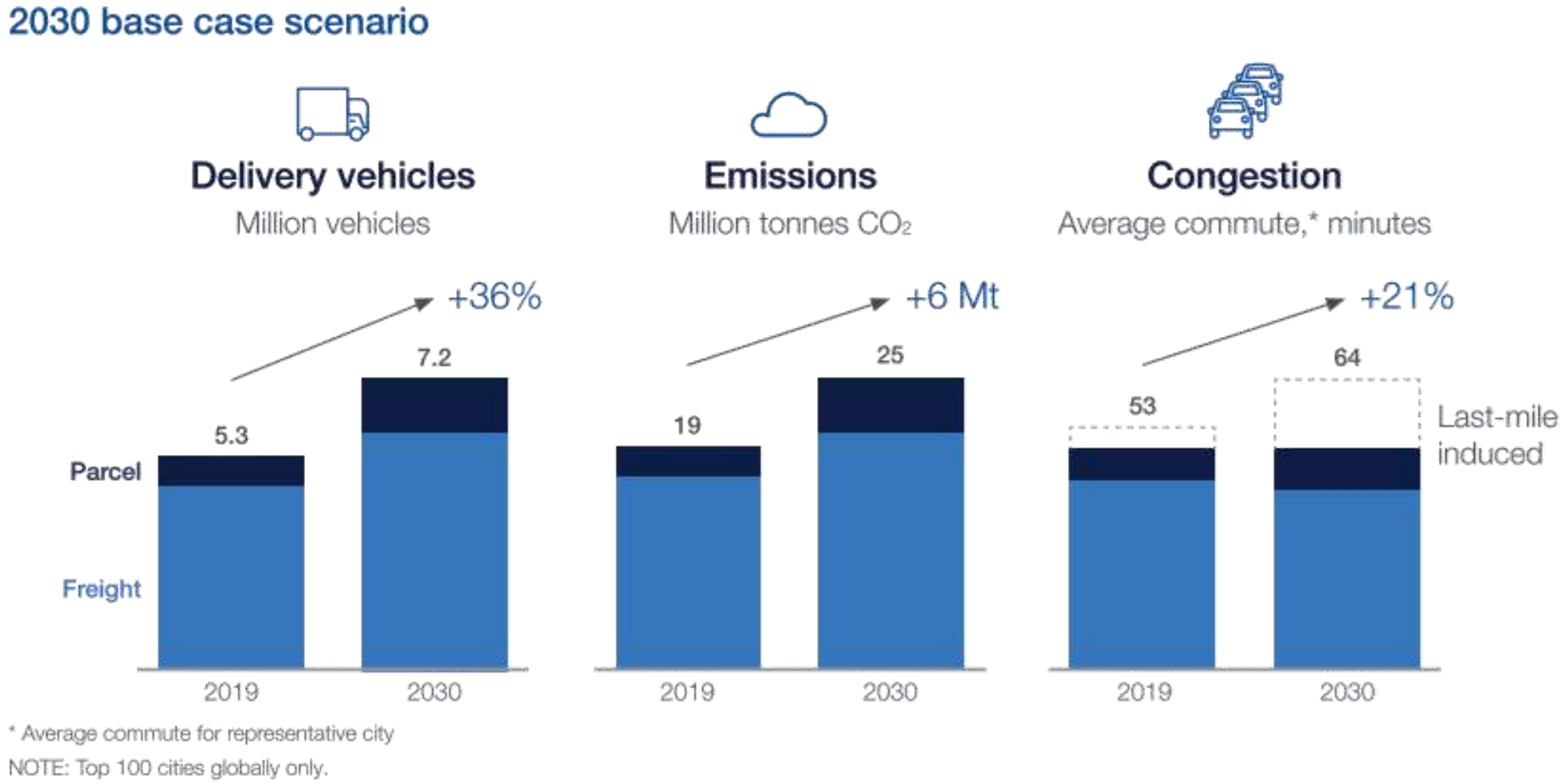
Autonomous vehicles' for e-commerce deliveries: what's the buzz about?

Double-digit e-commerce growth in the past decade, accelerated by the pandemic



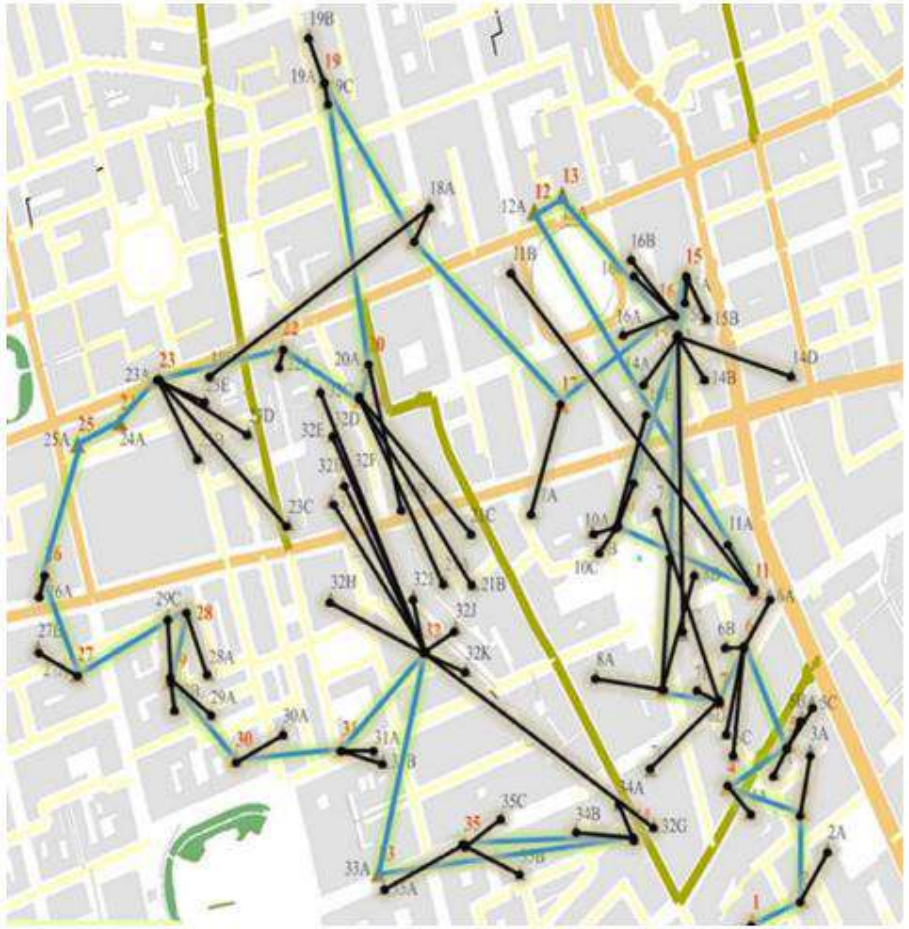
Reference: International Post Corporation, 2021

E-commerce deliveries generate significant externalities, especially in cities



Reference: Deloison et al., 2020

E-commerce deliveries in cities are largely inefficient: example from London

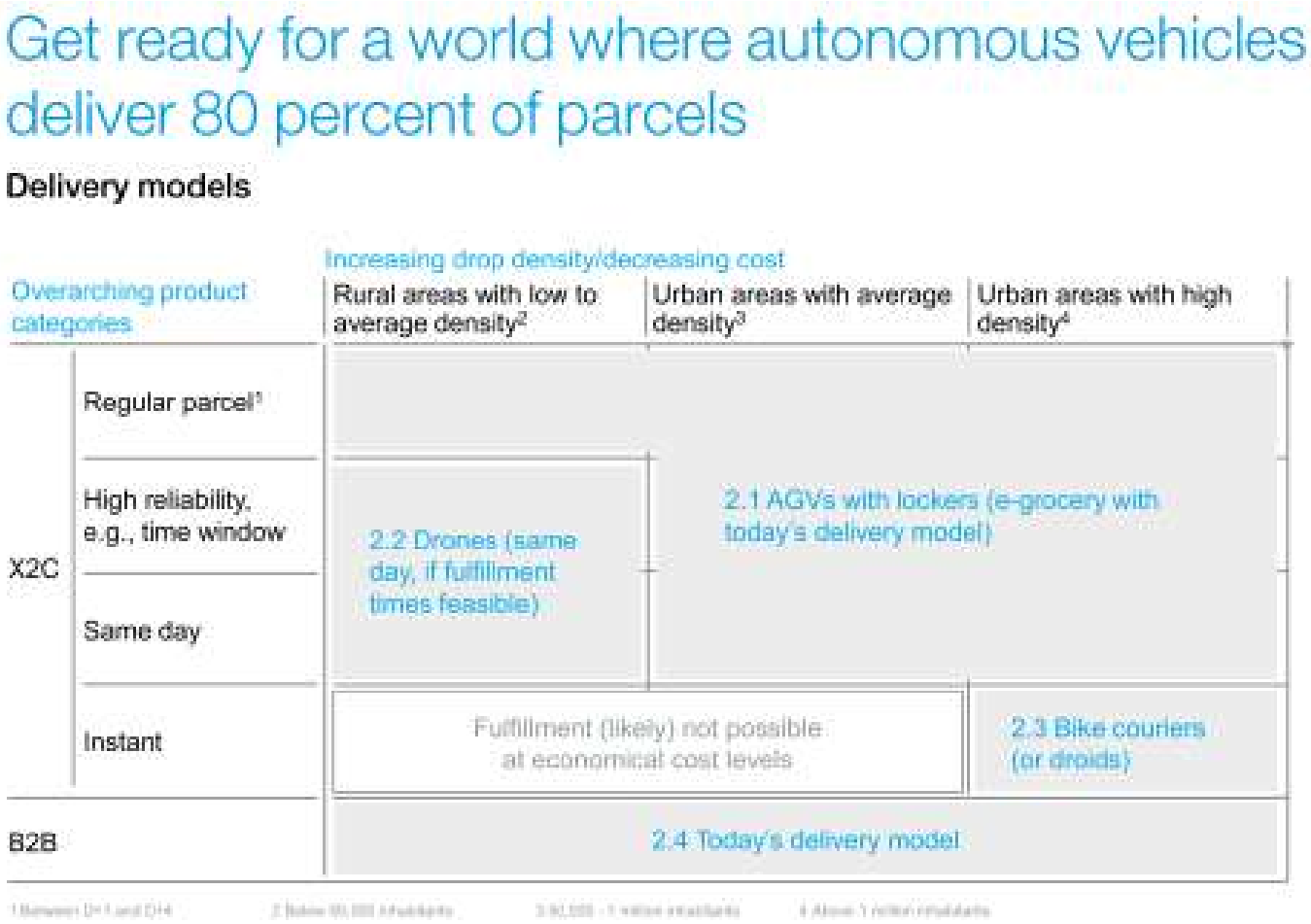


Vehicle round statistics for parcel deliveries (n = 25)

Vehicle round statistic	Mean	Unit
Round duration, of which:	7.3	hour
- vehicle parked	62%	%
Driving distance within delivery area	11.9	km
Average vehicle speed within delivery area	7.0	kph
No. of items delivered and (collected)	118 (9)	#
Total walking distance	7.94	km
Average walking distance per customer	105	m/customer
No. of customers served	72	#
No. of parking stops, of which:	37	#
- proportion on street	95%	%
Time taken to deliver or collect (once parked)	4.1	min/customer

Reference: Allen et al., 2018

Autonomous vehicle technology as solution to externalities and inefficiencies?



Reference: Joerss et al., 2016

Autonomous vehicle technology as solution during a health crisis?

A self-driving vehicle delivers lunch boxes to workers in Pingshan District in Shenzhen.

Postmates delivery robots deliver food in Los Angeles.

Colombian delivery app Rappi is testing robotic deliveries in Medellin.

A self-driving Starship robot drops off deliveries in Emerson Valley, Britain.

Reference: Guizzo, 2020; Meisenzahl, 2020

What is the state of practice and future potential of autonomous vehicles for e-commerce delivery in cities?

Methodological approach combining desk and field research

Meta-analysis of the literature on autonomous e-commerce deliveries

- Including white papers; trend reports; newspaper articles; press releases; and scientific articles, more than one hundred references
- March until September 2020
- Information on company; vehicle; and test, based on approximately seventy autonomous e-commerce delivery initiatives

Desk research

Questionnaire among transport companies

- Panel of transport companies, ten completed surveys
- July 2020 until September 2020
- Information on level of interest; perceived benefits and obstacles; and perceived impact of the health crisis

Interviews with a transport company and autonomous vehicle developers

- Four semi-structured expert-interviews
- August 2020 until September 2020
- Information on state of practice, experiences and expectations; vehicle design; regulation, costs and infrastructure conditions; perceived benefits and obstacles; and perceived impact of the health crisis

Field research

Methodological approach combining an international context and a French case-study

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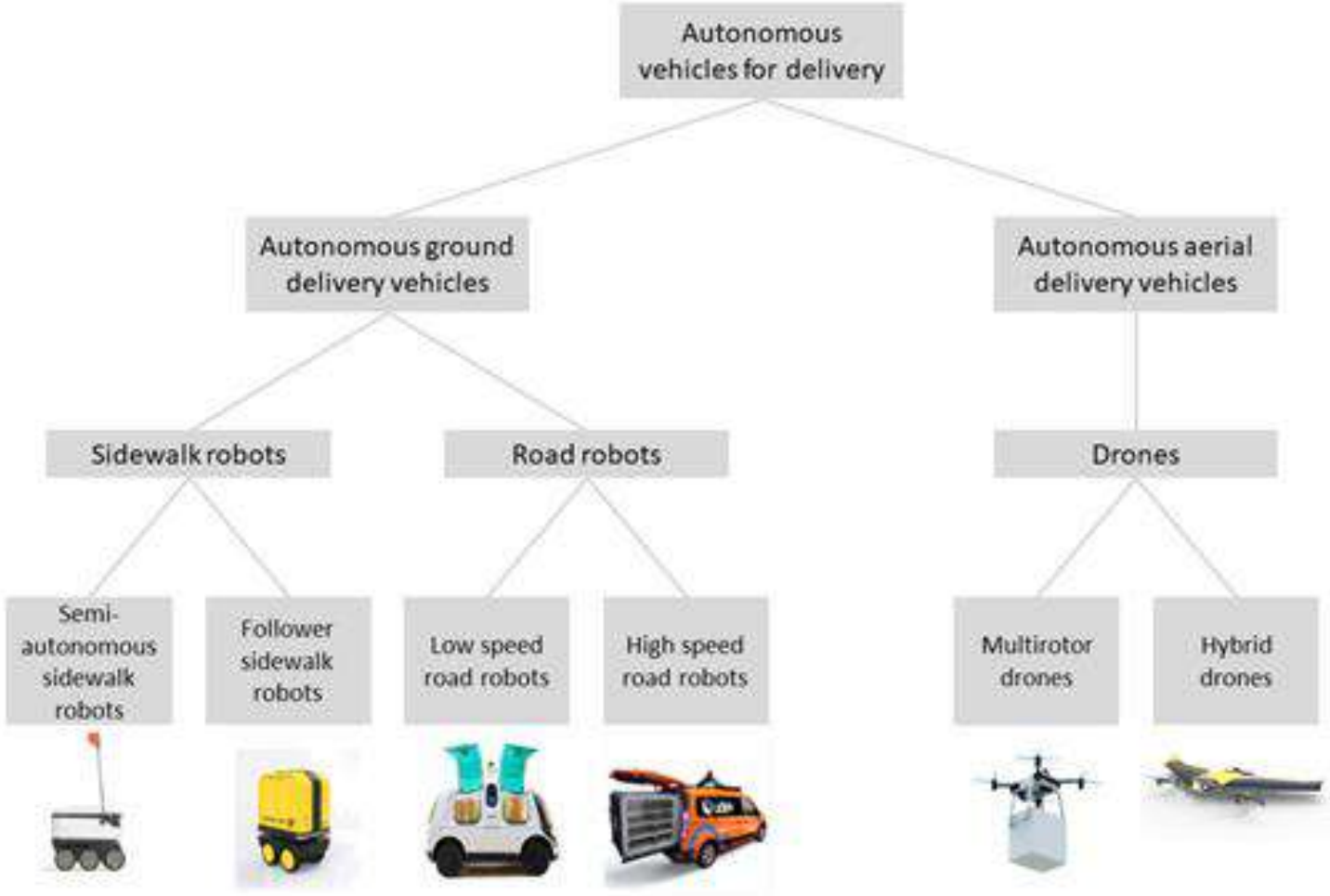
Overview of international developments

Overview of developments in France

Typology of autonomous e-commerce delivery vehicles based on differences in infrastructure, speed, automation level, size and carrying capacity



Reference: Touami, 2020

Multirotor (quadcopters, hexacopters, octocopters) and hybrid drones (wings)

Infrastructure: air
Speed: 60 km/h for multirotor drones, 120 km/h for hybrid drones
Automation: between level 3 and 4, able to make some decisions but human supervision necessary
Carrying capacity: up to 5 kg for multirotor drones, up to 25 kg for hybrid drones

Image: Atechsys

Semi-autonomous sidewalk robots

Infrastructure: sidewalks
Speed: max 6 km/h
Automation: overall level 3, travel autonomously but are supervised, Serve Robotics recently became first to commercially launch level 4 sidewalk robots (Auto Futures, 2022)
Carrying capacity: between 10 and 40 kg, up to a maximum of 350 kg in a few cases

Image: DeliRo, ZMP

Follower sidewalk robots

Infrastructure: sidewalks
Speed: same as assisted person
Automation: level 3
Carrying capacity: up to 1000 kg

Image: Gita, Piaggio Fast Forward

Low and high-speed road robots

Infrastructure: roads
Speed: 40 km/h for low-speed road robots, 80 km/h for high-speed road robots
Automation: level 4
Carrying capacity: similar to regular vans

Images: R2, Nuro & Udelv

Typology of autonomous e-commerce delivery scenarios

(1) Follower robot model

(2) Van-robot model

(3) Sidewalk robot model

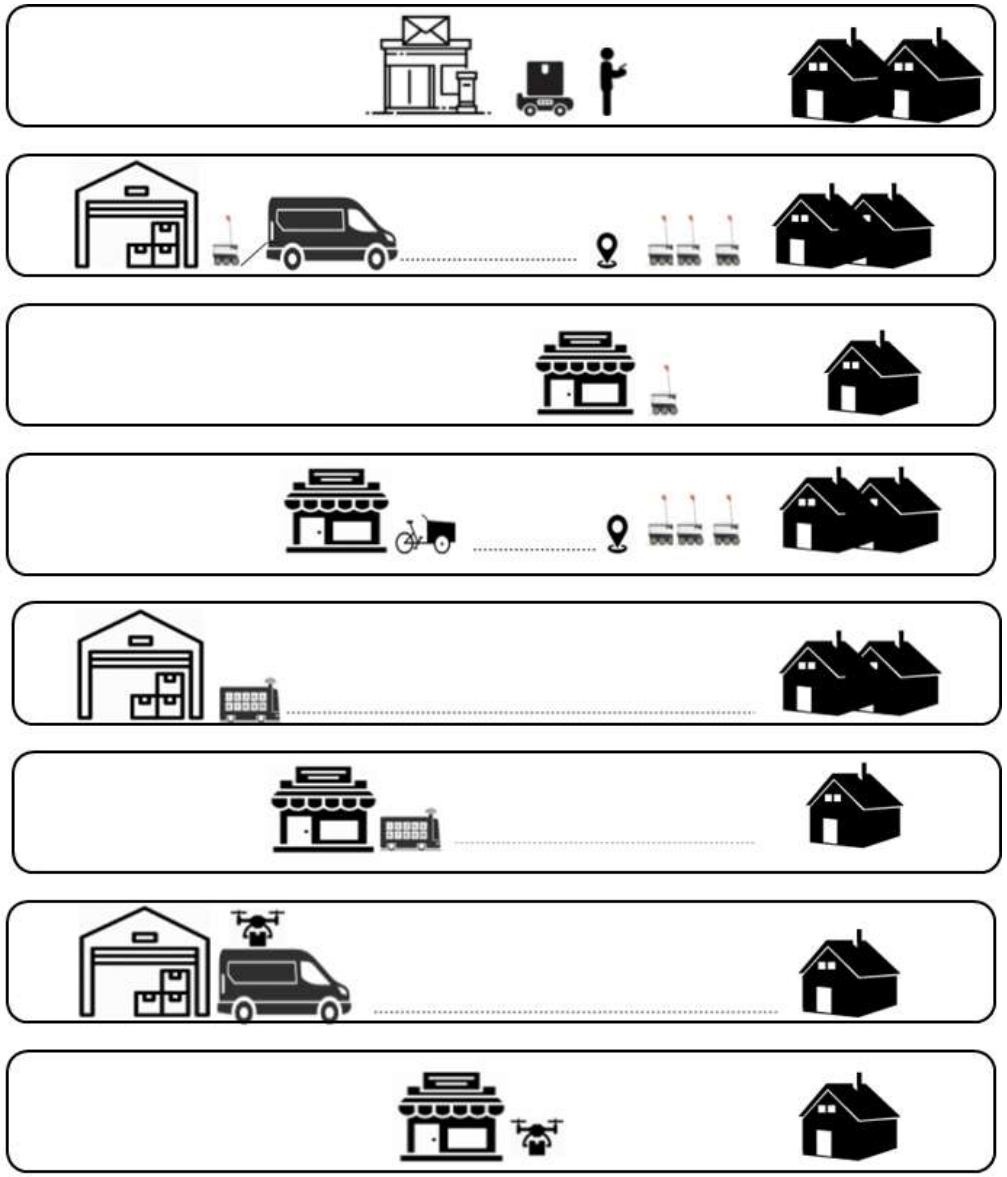
(4) Robot-cargobike model

(5) Warehouse-road robot model

(6) Store-road robot model

(7) Van-drone model

(8) Drone model



Reference: Touami, 2020

The French autonomous delivery vehicle market

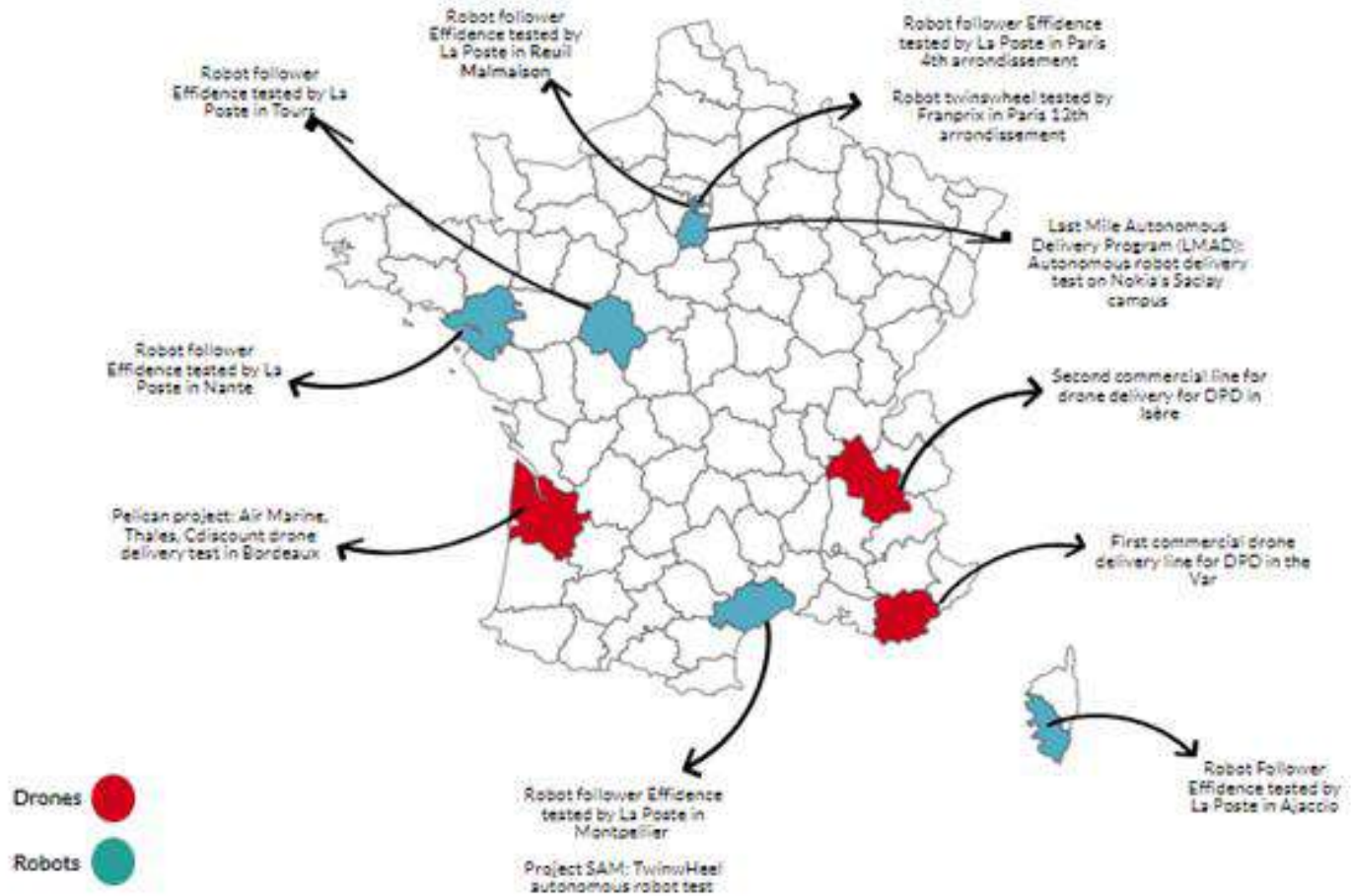
Effidence follower robot

TwinswHeel follower robots

Sterela sidewalk robot

Valeo road robot

Autonomous delivery vehicle tests and applications in France, mostly by La Poste, none during lockdown



Reference: Touami, 2020

Autonomous delivery vehicle tests during lockdown elsewhere, especially in the US and China

Zipline in North Carolina (Bright, 2020).

White Rhino Auto in Wuhan (Gong, 2019).

Country	Company	Vehicle type	City	Delivery scenario	Product type
United States	Starship Technologies	Sidewalk robots	Tempe, Washington DC, Irvine	Sidewalk robot model	Prepared meals, groceries
	Nuro	Road robots	Houston, Bay Area, San Mateo	Store-road robot model	Prepared meals, groceries, medical supplies
	Kiwi Campus	Sidewalk robots	Berkeley, San Jose	Sidewalk robot model	Prepared meals, groceries, medical supplies
	Pony.ai	Road robots	Fremont, Irvine	Warehouse-road robot model	Prepared meals, groceries
	Cruise	Road robots	San Francisco	Store-road robot model	Groceries
	Postmates	Sidewalk robots	San Francisco, Los Angeles	Sidewalk robot model	Prepared meals
	Zipline	Drones	North Carolina	Drone model	COVID-19 tests, medical supplies
	Flytrex	Drones	Grand Forks, North Dakota	Drone model	Groceries
	Waymo	Road robots	Bay Area	Store-road robot model	Parcels
	Wing	Drone	Christiansburg, Virginia	Drone model	Groceries
	Amazon Scout	Sidewalk robots	Snohomish, Irvine	Sidewalk robot model	Parcels
	Navya	Shuttle	Jacksonville	Store-road robot model	Prepared meals, medical supplies
	Refraction AI	Road robots	Ann Arbor	Store-road robot model	Prepared meals, groceries
	Optimus Ride	Road robots	The yard, Washington DC	Store-road robot model	Prepared meals
England	Starship Technologies	Sidewalk robots	Milton Keynes	Sidewalk robot model	Prepared meals, groceries
Scotland	Wingcopter	Drones	Isle of Wight, Isle of Mull	Drone model	Medical supplies
	Skyport	Drones	Argyll and Bute	Drone model	Medical supplies
Ireland	Manna Aero	Drones	Moneygall	Drone model	Medical supplies, basic necessities
Finland	LMAD - Last Mile Autonomous Delivery	Sidewalk robots	Helsinki	Sidewalk robot model	Groceries
China	Unity Drive Innovation	Sidewalk and road robots	Zibo, Suzhou, Shenzhen	Store-road robot model	Groceries
	White Rhino Auto	Road robots	Wuhan	Store-road robot model	Prepared meals, medical supplies
	Neolix	Road robots	Wuhan	Store-road robot model	Prepared meals, groceries, medical supplies
	Neolix	Road robots	Wuhan	Warehouse-road robot model	Parcels
	JD Logistics	Road robots	Wuhan	Store-road robot model	Groceries, parcels
	JD Logistics	Drones	Wuhan	Drone model	Medical supplies
	Meituan Dianping	Sidewalk robots	Beijing	Sidewalk robot model	Groceries
	Meituan Dianping	Road robots	Beijing	Store-road robot model	Groceries
	Antwork Network Technology	Drones	Beijing	Drone model	Medical supplies
	ZhenRobotics	Sidewalk robots	Beijing	Sidewalk robot model	Groceries
Canada	Tiny Mile	Sidewalk robots	Toronto	Sidewalk robot model	Prepared meals
	Drone Delivery Canada	Drones	Georgina Island	Drone model	Medical supplies
Russia	Yandex.Rover	Sidewalk robots	Moscow	Sidewalk robot model	Parcels
Rwanda	Zipline	Drones	Kigali	Drone model	COVID-19 tests, medical supplies
Ghana	Zipline	Drones	Accra, Kumasi	Drone model	COVID-19 tests, medical supplies
Australia	Wing	Drones	Canberra, Logan	Drone model	Prepared meals, medical supplies
Colombia	Kiwi Campus	Sidewalk robots	Medellin	Sidewalk robot model	Prepared meals

Starship in Mountain View (Forestieri, 2020).

Reference: Buldeo Rai, Touami & Dablanc, 2022

Three developments facilitated the testing and implementing of autonomous delivery vehicles

(1) Easing of regulation, examples:

- Waiver of Zipline by the Federal Aviation Administration to use drones for medical supplies in North Carolina (Bright, 2020).
- Permission for Nuro to continue testing its R2 road robots in California (Hawkins, 2020).
- Authorisation of White Rhino Auto to supply medical staff in Wuhan (Gong, 2019).
- Agreement by Mountain View's city council for Starship to launch its commercial services (Forestieri, 2020).

(3) Repurposing of activities towards delivery, example:

- Pony.ai, Waymo and Navya repurposed their autonomous vehicles from passenger transport and taxi activities.

(4) Extending of investments funds, example:

- Waymo signed a partnership with Walmart and UPS after repurposing its activities to goods delivery, extending its funding round of $2.25 billion in March with an additional $750 million in May from several new investors.
- Over a few months, investors injected at least $6 billion into autonomous delivery vehicle companies (Lienert & Lanhee Lee, 2020).

Several barriers for testing and implementing of autonomous delivery vehicles in France

Urban design characteristics, including of university campuses, considered more appropriate in the US.

Investment culture, US and Asian countries considered "more open to technology" and "more willing to invest in order to broaden the field of experimentation".

Focus on personal vehicle automation, instead of goods vehicles.

Regulation, and specifically the lack of transparency on authorisations in charge of the regulation.

Vehicle unit costs, high due to "high quality and small scale" local production ($5,500 and $2,250 (Starship estimates) vs €45,000 and €65,000 (TwinswHeel estimates)).

Dual role of public opinion, innovation vs loss of jobs/human contact.

Future potential of autonomous e-commerce delivery in France?

Estimation: up to a quarter of the e-commerce volume delivered autonomously within ten years.

Thank you! Questions?

Contact me at
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This research has been published in Research in Transportation Business & Management: https://doi.org/10.1016/j.rtbm.2021.100774

It is based on the Master thesis of Sabrina Touami (in French): https://www.lvmt.fr/wp-content/uploads/2020/11/TOUAMI-m%C3%A9moire-version-chaire.pdf

An overview of autonomous e-commerce delivery initiatives is published on the Logistics City Chair website: https://www.lvmt.fr/wp-content/uploads/2020/11/TOUAMI-m%C3%A9moire-annexe.pdf).

More information and resources:
https://www.lvmt.fr/en/chaires/logistics-city/

Transport companies sample of online questionnaire

Companies	Size	Product type	Segment type	Activity type
Company 1	Large	Parcels, food	B2C and B2B	In-house
Company 2	Large	Parcels, medication	B2C and B2B	Subcontracted
Company 3	Large	Parcels, cargo	B2B	Both
Company 4	Large	Prepared meals, food	B2C and B2B	Both
Company 5	Small-to-medium sized	Parcels, prepared meals, food	B2C and B2B	In-house
Company 6	Small-to-medium sized	Parcels, prepared meals, food	B2C and B2B	In-house
Company 7	Small-to-medium sized	Parcels, prepared meals, food	B2C and B2B	In-house
Company 8	Small-to-medium sized	Parcels, medication	B2C and B2B	In-house
Company 9	Small-to-medium sized	Medication, prepared meals	B2C and B2B	Subcontracted
Company 10	Small-to-medium sized	Medication	B2C	In-house

Reference: Buldeo Rai, Touami & Dablanc, 2022

Autonomous vehicle developers of semi-structured expert-interviews

Company	Activity	Interview information
Sterela	Engineering and services company. Developed a range of sidewalk delivery robots: Cargobot mule, Cargobot City, CargoBot XS.	Telephone interview on August 26th, 2020 with the Innovation & Development manager.
TwinswHeel	Start-up specialising in the design of sidewalk delivery robots. Developed three robots with different load capacities: TH03, TH05, TH05 cargo.	Telephone interview on August 27th, 2020 with the Founder.
LMAD - Last Mile Autonomous Delivery	Software company that developed a platform to manage and optimise fleets of autonomous vehicles for delivery. Carried out tests in France and Finland with robots from the Finnish autonomous vehicle developers GIM.	TEAMS interview on September 15th, 2020 with the CEO.

Reference: Buldeo Rai, Touami & Dablanc, 2022

Tests and applications of autonomous delivery vehicles in France

Company	Vehicle type	Type of initiative	Location	Timing
TwinswHeel	Follower sidewalk robots	Test with La Poste	Montpellier	End of 2020
TwinswHeel	Follower sidewalk robots	Test with supermarket chain Franprix	Paris	April 2019
DPD	Drone	Commercial line	Isère	2019
LMAD - Last Mile Autonomous Delivery	Sidewalk robots	Test with GIM Robotics	Paris	2019
Effidence	Follower sidewalk robots	Test with La Poste	Rueil Malmaison, Paris, Ajaccio, Montpellier, Nantes, Tours	Between April 2018 and July 2019
Air Marine	Drone	Test with Cdiscount	Bordeaux	2018
DPD	Drone	Commercial line	Var	2016

Reference: Buldeo Rai, Touami & Dablanc, 2022