An exploration of the potential benefits of Transportation and Logistics innovations in Last-Mile Urban Deliveries: A case study approach

L. Meherishi, C. Harter, D. Ciprés, J.L. López, **K. Zavitsas**

Last Mile Delivery challenges

- accounts for 40% of delivery costs and time
  - congested urban areas
  - dealing with traffic
  - finding appropriate parking
- e-commerce has made deliveries smaller and more frequent
- in-practice VRP variants used for planning
- organizational silos
- lack of evidence (financial)

- Advance the EUs strategy for Smart, Green and Integrated Transport & Logistics
- Development of EGTN concept

Green EU-Global Trade & Logistics Networks

(International Logistics Systems)

Infrastructure

about this research

scope

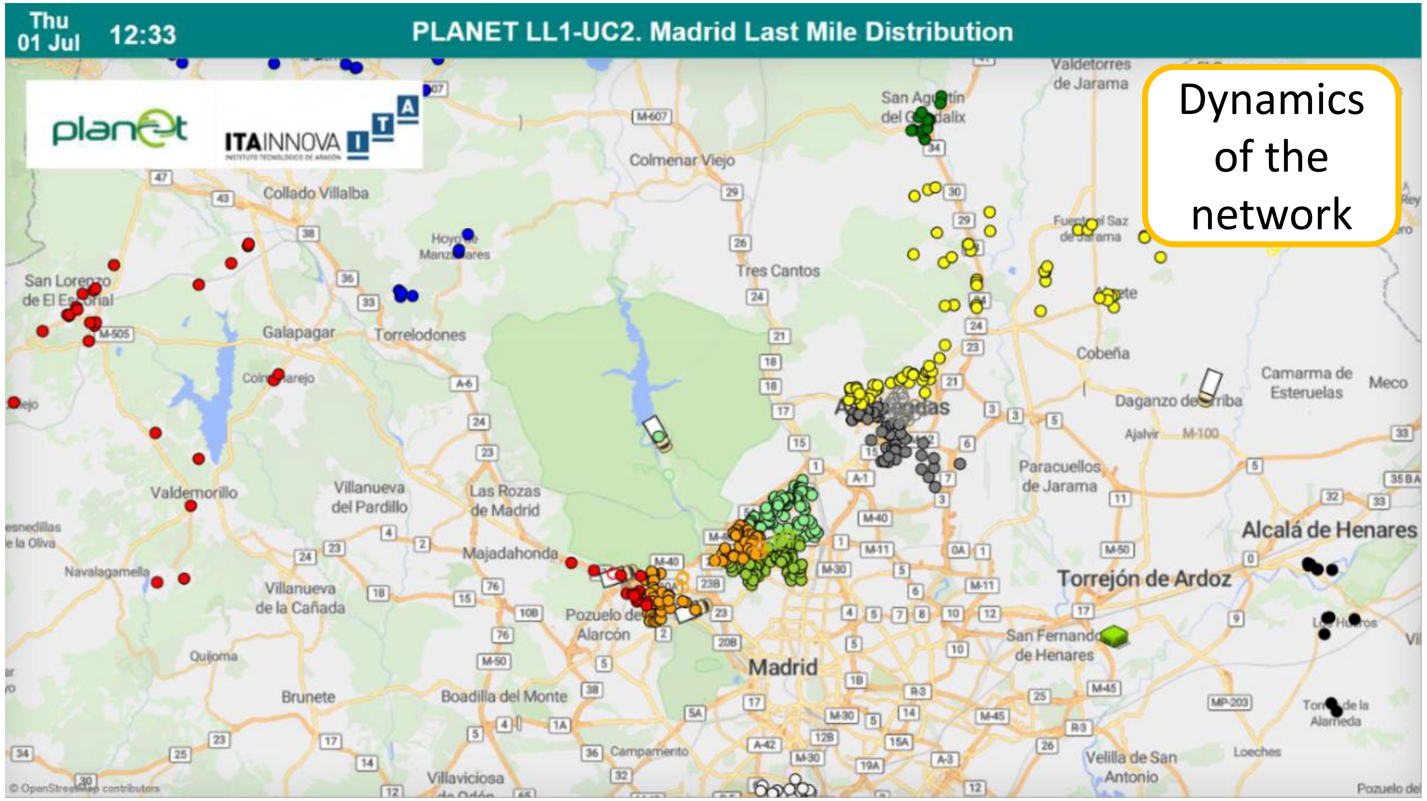
- integration of **collaborative** and Physical Internet principles in LMD operations
- Enable efficient urban logistics and to aid the transition towards a PI paradigm
- simulated environment through the development of a digital twin to analyse
  - Order sharing
  - Fleet sharing
- Research questions after Literature Review:
  - Analyse impact of PI strategy through DT
    - Order-sharing
    - Dynamic fleet-sharing
  - Green vehicles performance in PI

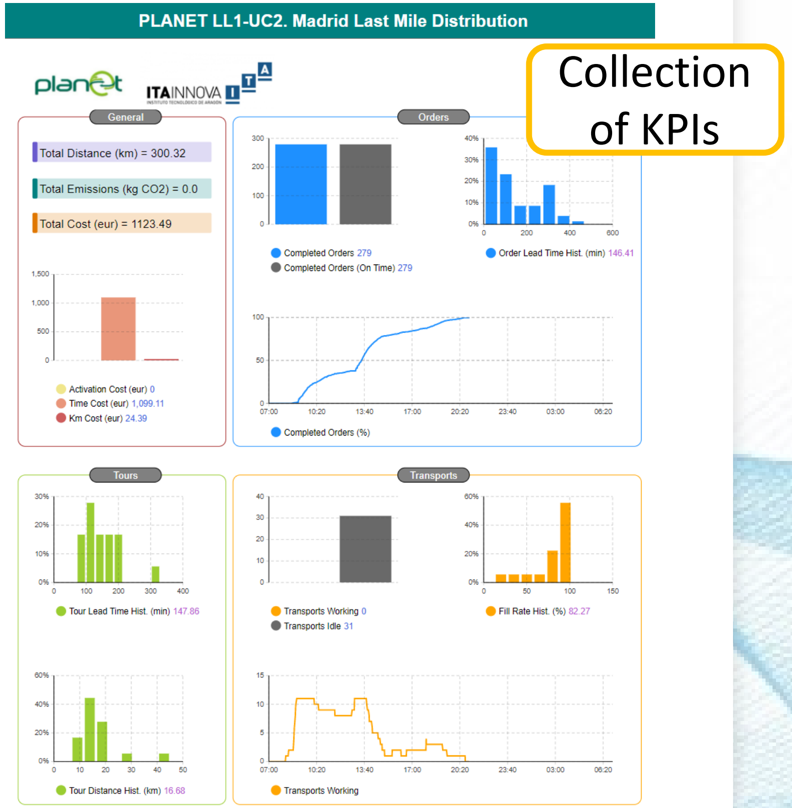
approach

- Baseline (as-is) scenario:
  - multiple companies deliver parcels to customers using their own distribution centres and fleet
- Collaboration scenario:
  - companies' distribution centres are used as shared urban consolidation centres (UCC), in which orders can be redistributed and vehicles can be shared
  - a dynamic reshuffling process is established in this scenario, which matches delayed vehicles with vehicles that have buffer capacity to mitigate the impact of arising delays in daily operations.
- Collaboration + green vehicles scenario:
  - complemented by the use of green vehicles and cargo bikes to further drive down emissions and assess if there is an associated performance loss.

Digital Twin

A **digital twin** was developed using **multi-agent simulation** techniques, incorporating information about the logistics network, process characterization, parameters, algorithms, and logical rules. This approach enables the **simulation of complex scenarios**, testing of potential solutions, and provides insights into the network's performance and optimization possibilities.





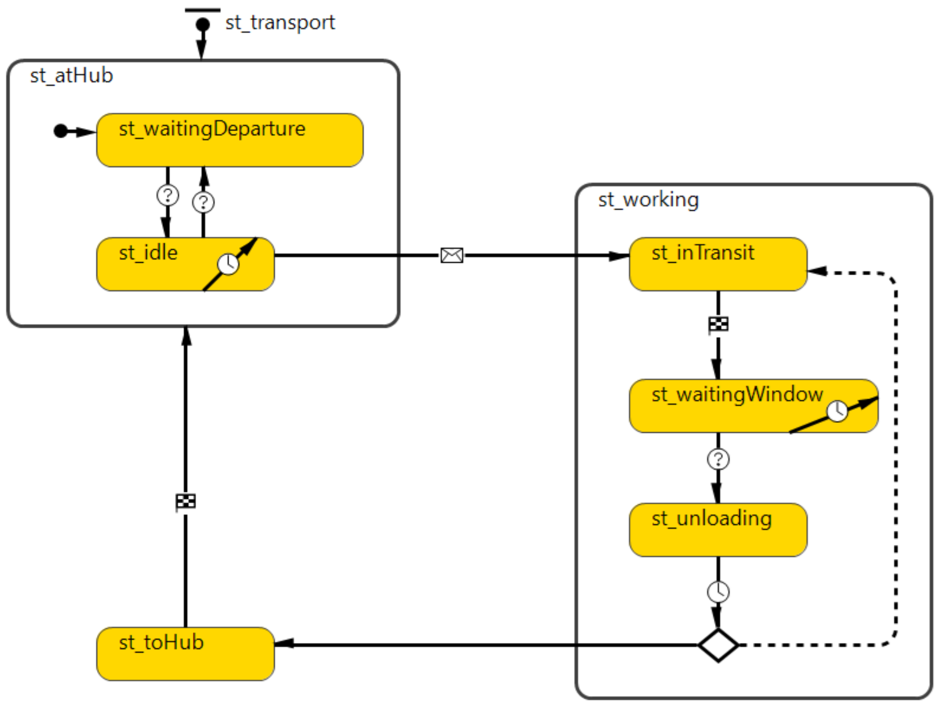
Digital Twin

The digital twin utilizes **multi-agent** simulation techniques to represent key agents and their **interactions within the last mile delivery network**. Agents have their own states, make intelligent decisions, communicate, and respond to changes and parameters.

Main agents:

- **Hubs:** represent places where goods are stored, transferred, or handled in the network, and from where vehicles depart.
- **Orders:** customer demand. Encapsulate goods in intelligent and interconnectable modular containers, enabling efficient flow in hyperconnected logistics networks.
- **Tours:** routes assigned to vehicles to complete orders.
- **Transports:** vehicles that travel routes, delivering and picking up orders.

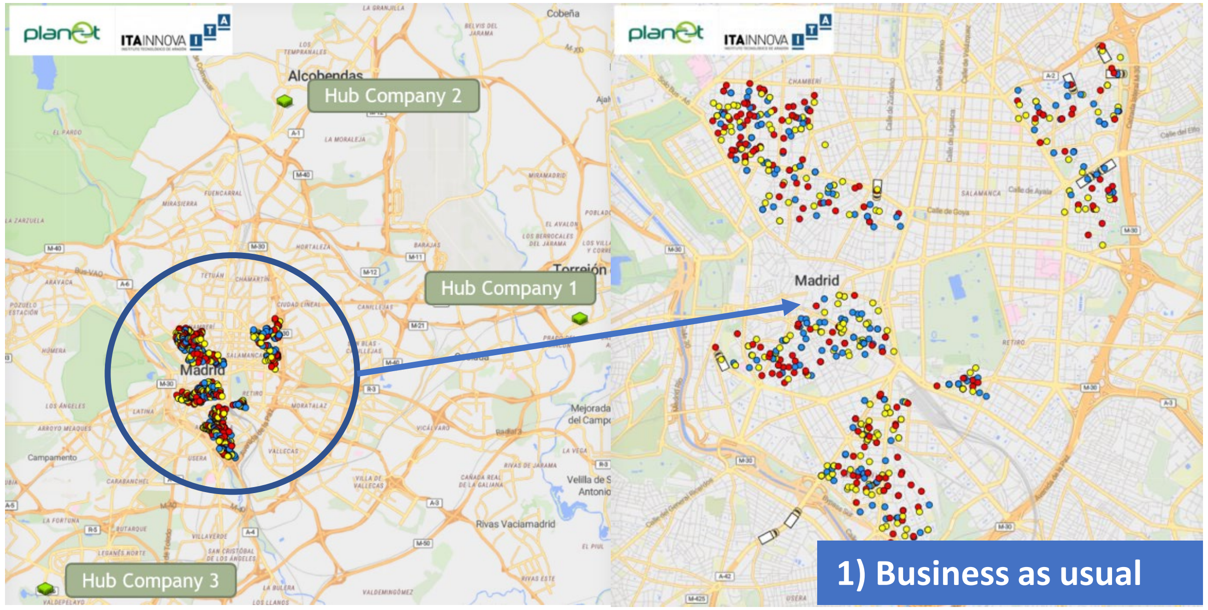
Example of state chart for transport agents

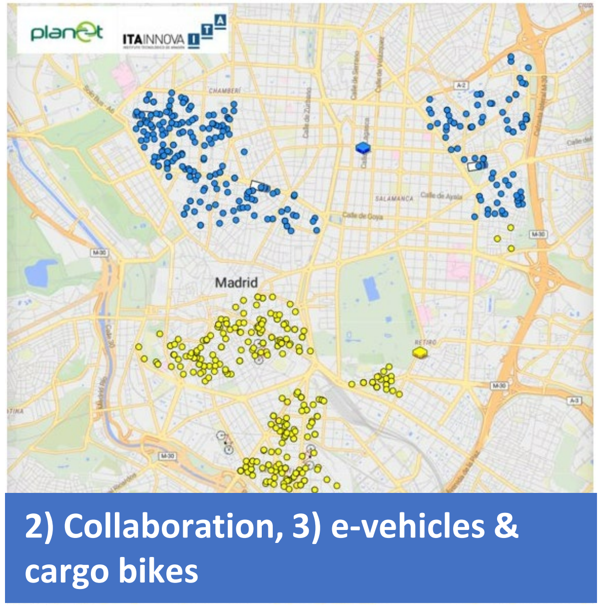


Digital Twin (Video)

IPIC 2023

Scenarios



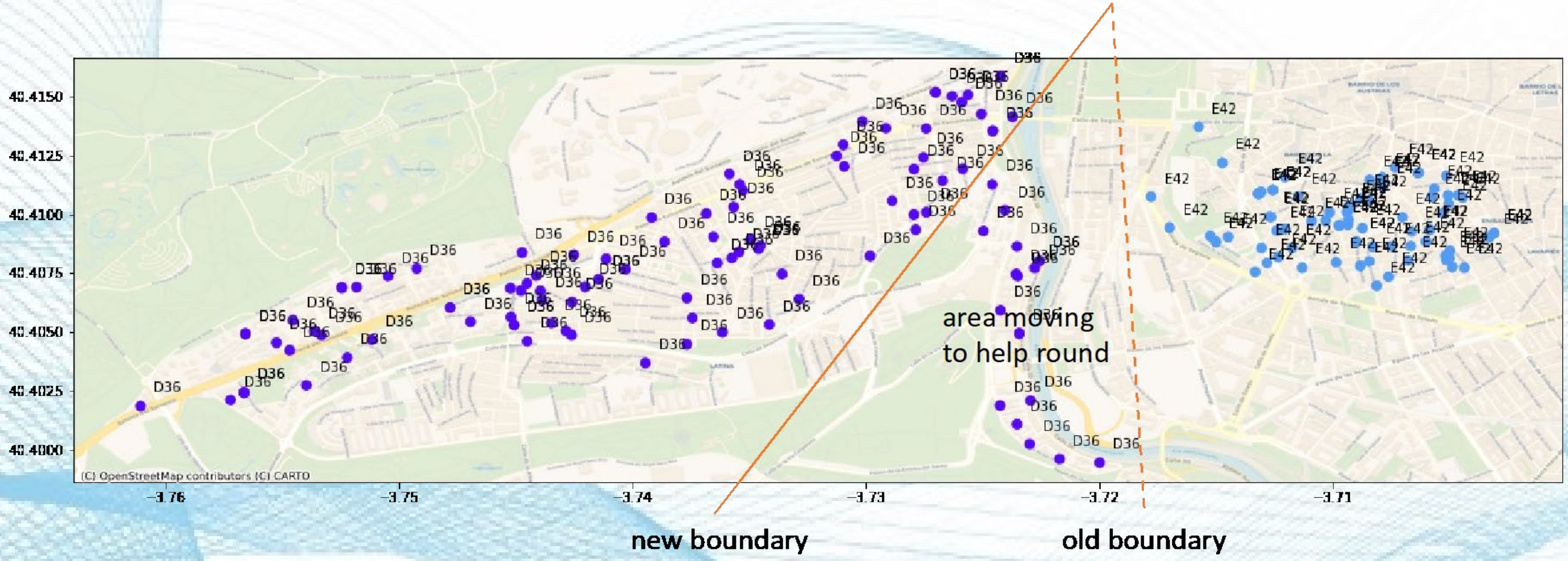


- Collaboration scenario:
  - two UCCs' for order sharing
  - fleet sharing/ parcel reshuffling

Technology/ Logistic innovation modelled	Characteristics considered	Scenarios		
		(i)	(ii)	(iii)
Physical internet	Open logistics environment to share asset (viz. trucks, depots) capacity, routes, and customer order data to improve the last-mile delivery performance.		✓	✓
IoT	End-to-end visibility over different operators and means of transport		✓	✓
Blockchain	Enabling technology for the Physical Internet, offering robust security measures and fostering trust in information exchange among operators		✓	✓
Optimized decision-making	•Vehicle routing Problem: Optimal routing of parcel deliveries in the last mile •Dynamic matching of delayed and non-delayed vehicles		✓	✓
Green Logistics (E-vans+cargo bikes)	Replacing the conventional diesel trucks with more sustainable vehicle options to carry out the last-mile deliveries			✓

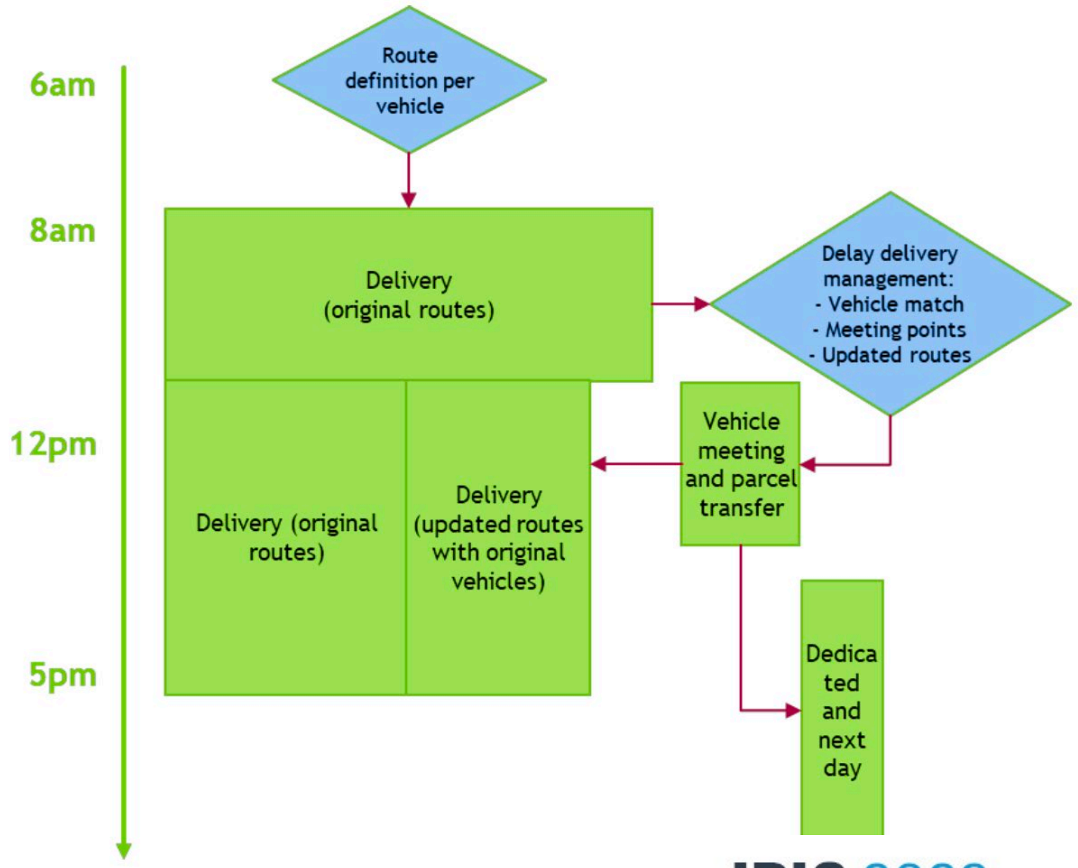
fleet sharing/ parcel reshuffling

- Last mile collaboration for dynamically addressing delays
- Automates and optimizes reshuffling process that is currently undertaken manually aiming to make it more efficient
- Interoperates with last mile routing service and HM interface



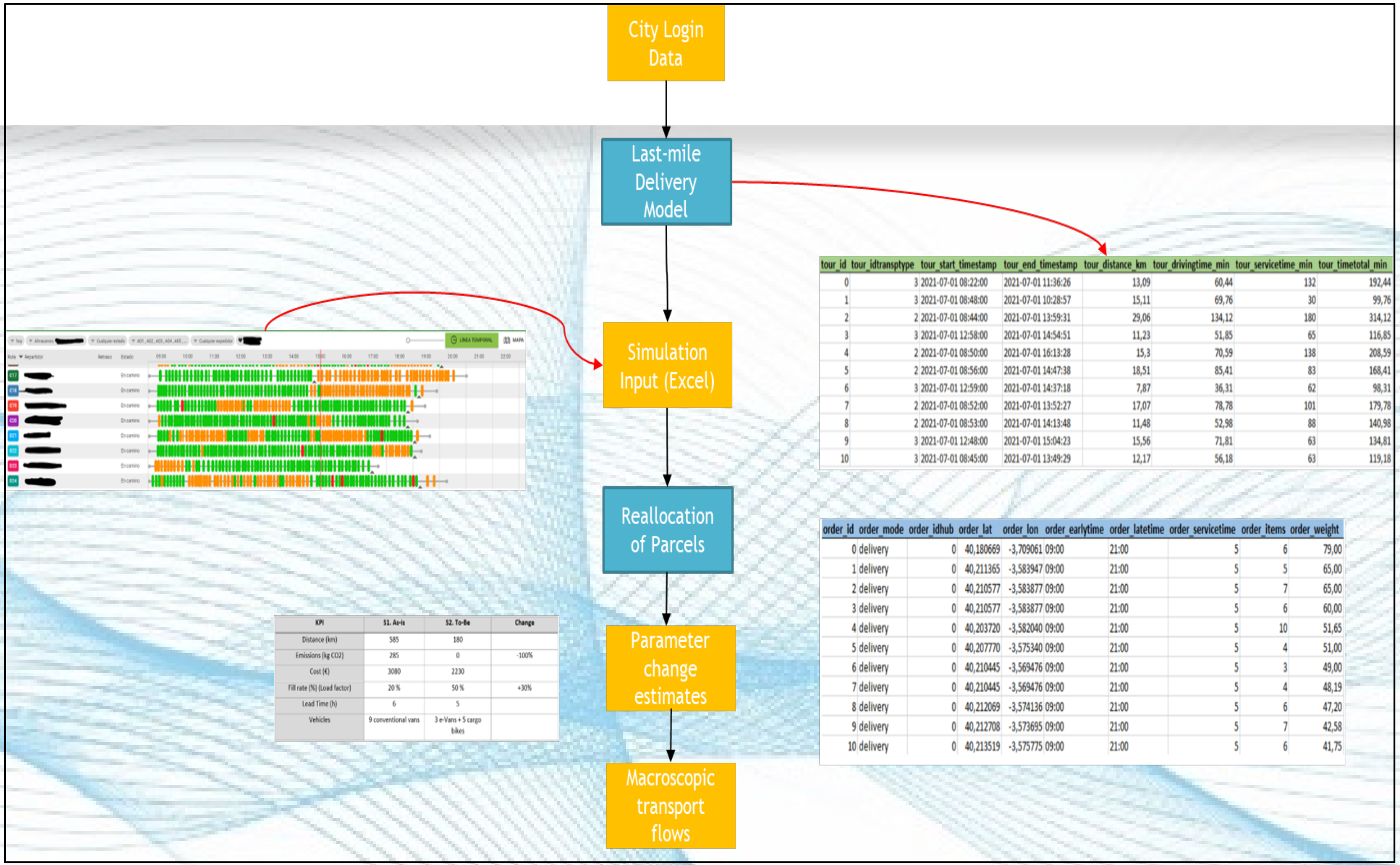
DT dynamic fleet handling

- DSS
  - tracks delivery progress
  - Effectively explores collaboration options in proximity
    - Single-operator
    - Multiple operators
  - Reroutes to alleviate late deliveries and non-completion



IPIC 2023

DT dynamic fleet handling

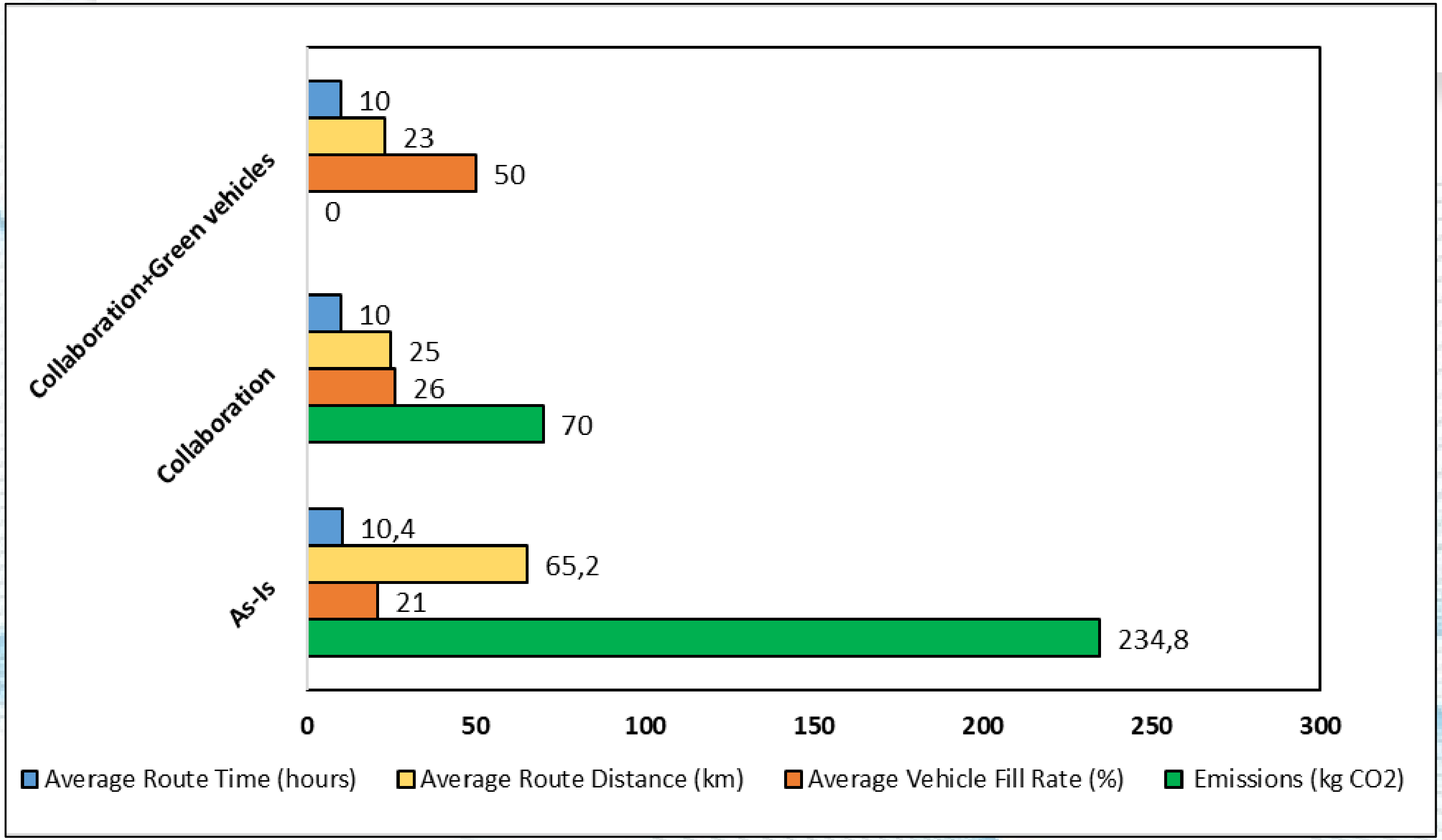


tour_id	tour_idtransptype	tour_start_timestamp	tour_end_timestamp	tour_distance_km	tour_drivingtime_min	tour_servicetime_min	tour_timetotal_min
0	3	2021-07-01 08:22:00	2021-07-01 11:36:26	13,09	60,44	132	192,44
1	3	2021-07-01 08:48:00	2021-07-01 10:28:57	15,11	69,76	30	99,76
2	2	2021-07-01 08:44:00	2021-07-01 13:59:31	29,06	134,12	180	314,12
3	3	2021-07-01 12:58:00	2021-07-01 14:54:51	11,23	51,85	65	116,85
4	2	2021-07-01 08:50:00	2021-07-01 16:13:28	15,3	70,59	138	208,59
5	2	2021-07-01 08:56:00	2021-07-01 14:47:38	18,51	85,41	83	168,41
6	3	2021-07-01 12:59:00	2021-07-01 14:37:18	7,87	36,31	62	98,31
7	2	2021-07-01 08:52:00	2021-07-01 13:52:27	17,07	78,78	101	179,78
8	2	2021-07-01 08:53:00	2021-07-01 14:13:48	11,48	52,98	88	140,98
9	3	2021-07-01 12:48:00	2021-07-01 15:04:23	15,56	71,81	63	134,81
10	3	2021-07-01 08:45:00	2021-07-01 13:49:29	12,17	56,18	63	119,18

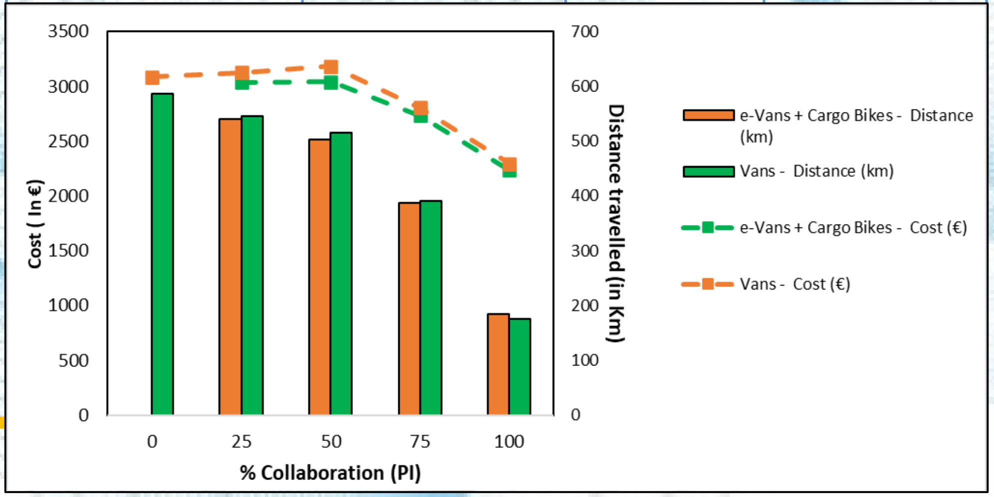
order_id	order_mode	order_idhub	order_lat	order_lon	order_earlytime	order_latetime	order_servicetime	order_items	order_weight
0	delivery	0	40,180669	-3,709061	09:00	21:00	5	6	79,00
1	delivery	0	40,211365	-3,583947	09:00	21:00	5	5	65,00
2	delivery	0	40,210577	-3,583877	09:00	21:00	5	7	65,00
3	delivery	0	40,210577	-3,583877	09:00	21:00	5	6	60,00
4	delivery	0	40,203720	-3,582040	09:00	21:00	5	10	51,65
5	delivery	0	40,207770	-3,575340	09:00	21:00	5	4	51,00
6	delivery	0	40,210445	-3,569476	09:00	21:00	5	3	49,00
7	delivery	0	40,210445	-3,569476	09:00	21:00	5	4	48,19
8	delivery	0	40,212069	-3,574136	09:00	21:00	5	6	47,20
9	delivery	0	40,212708	-3,573695	09:00	21:00	5	7	42,58
10	delivery	0	40,213519	-3,575775	09:00	21:00	5	6	41,75

KPI	S1. As-is	S2. To-Be	Change
Distance (km)	585	180	
Emissions (kg CO2)	285	0	-100%
Cost (€)	3080	2230	
Fill rate (%) (Load factor)	20 %	50 %	+30%
Lead Time (h)	6	5	
Vehicles	9 conventional vans	3 e-Vans + 5 cargo bikes	

Findings – impacts of technologies



KPI	S1. As-is	S2. To-Be	Change
Distance (km)	585	180	-69%
Emissions (kg CO2)	285	0	-100%
Cost (€)	3080	2230	-28%
Fill rate (%) (Load factor)	20 %	50 %	+30%
Lead Time (h)	6	5	-17%
Number and type of Vehicles	9 conventional vans	3 e-Vans + 5 cargo bikes	



concluding remarks

- DT can contribute to assess technology scenarios (IoT, blockchain, AI/ML, eVs) in LMD
- Order & fleet collaboration drives the majority of savings
- Parcel reshuffling
    - Single operator reshuffling meaningful in low-demand
    - Multiple-operator collaboration meaningful in high-demand
- Further research to address financial aspects, fully consider eVs operational constraints

thank you!

https://www.planetproject.eu

VLTN

Kostas Zavitsas

k.zavitsas@vltn.be