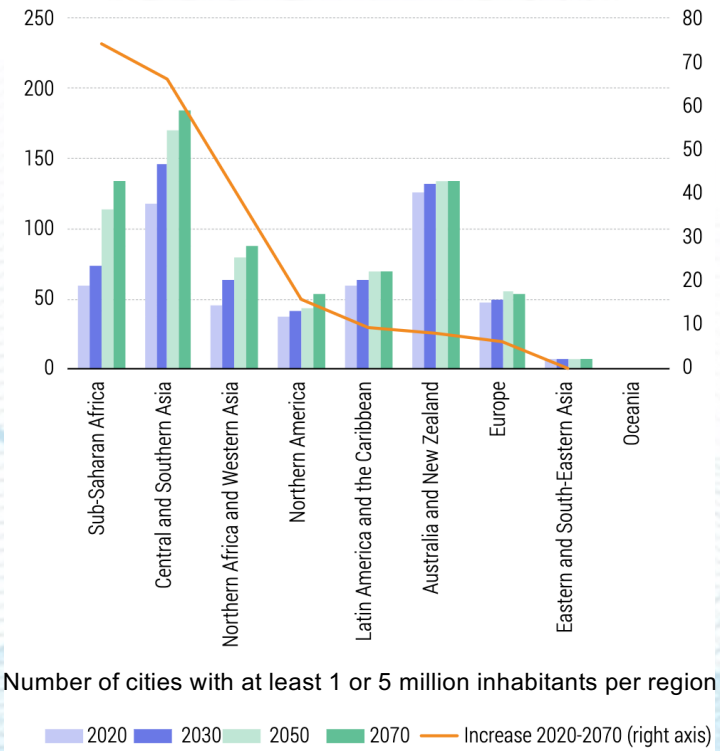


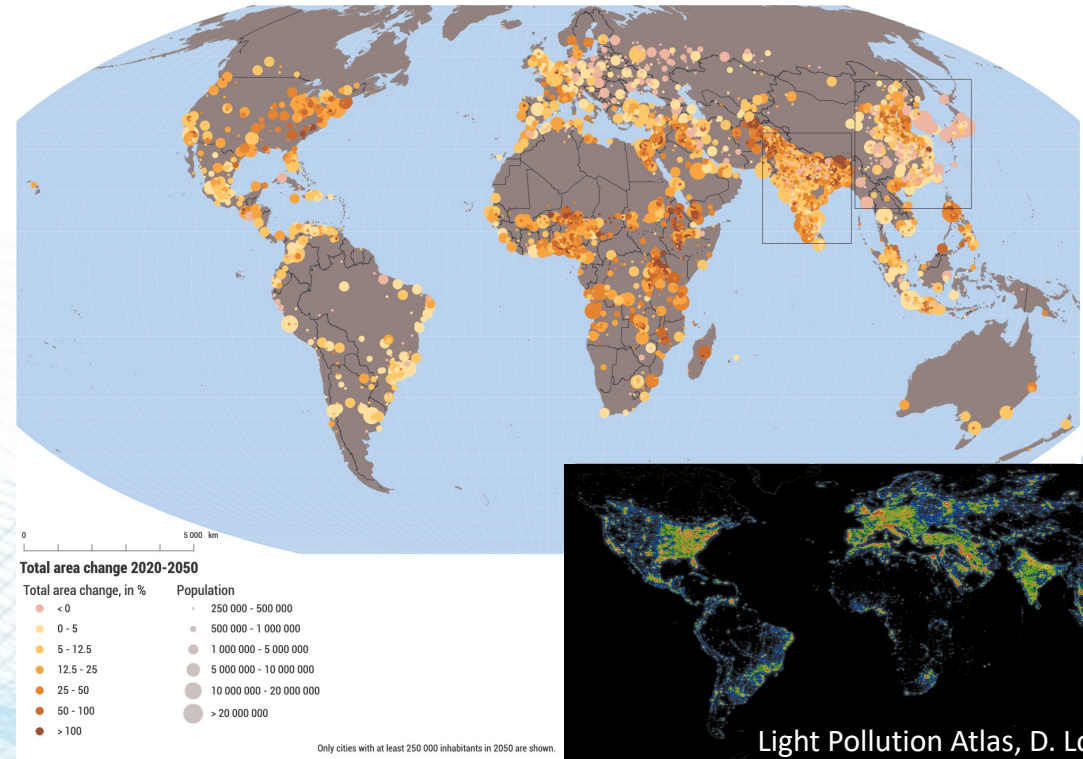
# Hyperconnected Urban Synchronomodality: Synergies between Freight and People Mobility

Olivier Labarthe, Walid Klibi, Benoit Montreuil, Jean-Christophe Deschamps

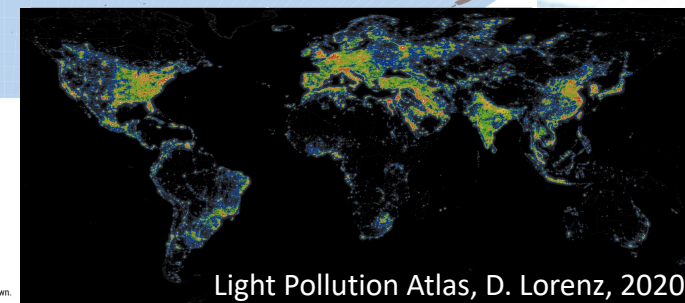
# Demographic and spatial growth of cities



Source : World Cities Report, UN, 2022



Source : World Cities Report, UN, 2022



**This evolution creates new demands for logistics services in urban areas**

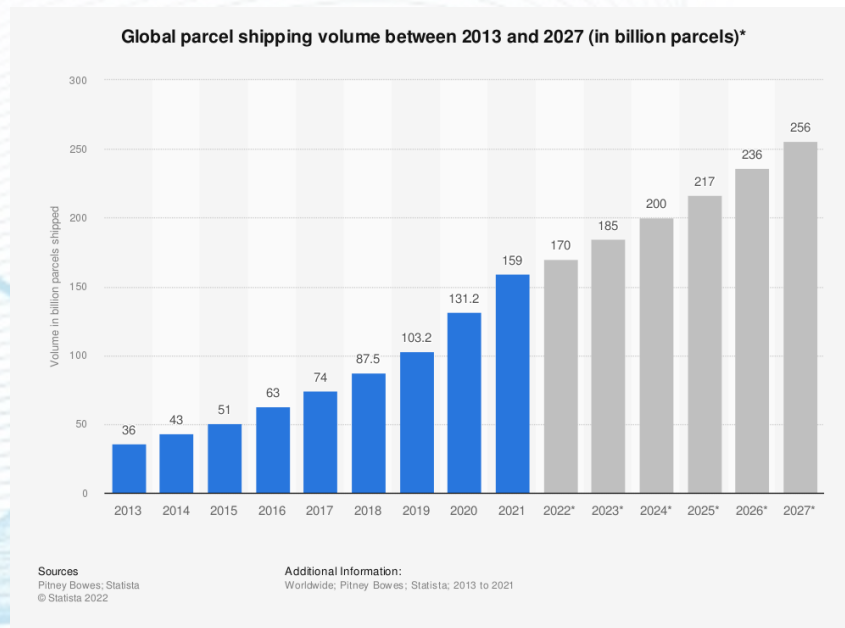


# Rise of e-commerce in deliveries

85% of the world's population will live in cities by 2050

New megacities are appearing especially in Latin America and Asia

More costs to deliver more air ?



More inefficiency ?

More greenhouse gas emissions ?  
More use of non-renewable fossil fuels ?



More traffic accidents/jam ?  
More ear and visual pollution ?

Lower volumes per shipment and higher number of shipments

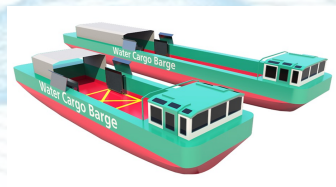
# Emergence of logistics solutions in urban areas

- Seeking for economic, environmental and societal efficiency
- Using clean energy for the **first-last mile** delivery
- Validating **low carbon solutions** for urban logistics

## Maritime

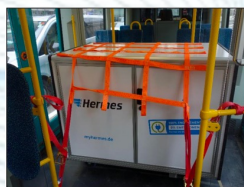


Fludis logistics boat



Water Cargo Barge

## Rail



LastMileTram



Source: JD.com

## Road



Toyota e-Palette Concept



Source: Taniguchi, 2018

## Air





# Connecting freight transportation systems

- Designing more efficient and **sustainable urban logistics**
- Encapsulating goods in smart easy-to-handle and modular **PI-containers**
- Enabling the emergence of **Urban Logistics Webs**



Van/trailer – Cubicycle  
Source : DHL Group, 2016



Truck – Cargo Bike  
City-Hub Rytle, 2018



Tramway - Cargo Bike  
LastMileTram, 2019



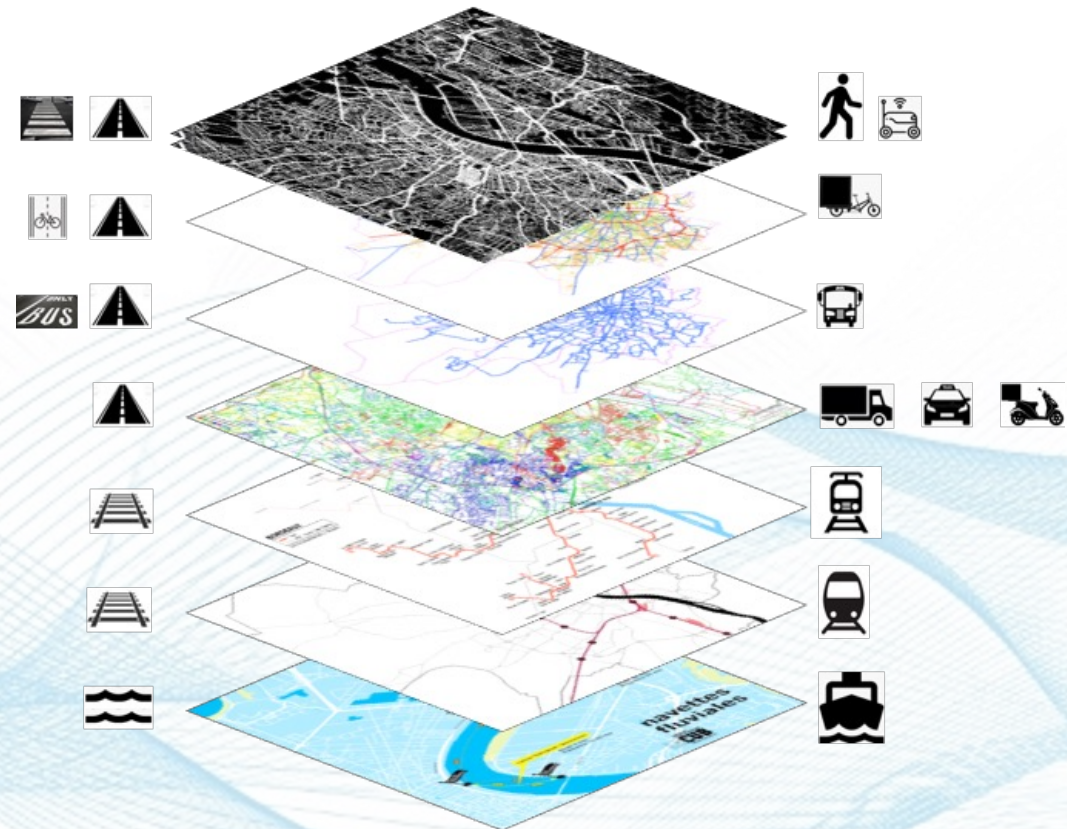
Barge – Cargo Bike,  
VNF, France, 2020



The Hub Company,  
2022

# Multilayer urban infrastructure

- Hyperconnected City Logistics calls for **novel approaches**
- Planning and responding for **capacity** and **resources** aligned with the emerging urban needs and challenges
- Relying on the potential of exploitation of a **network of networks**





# Multimodal urban mobility

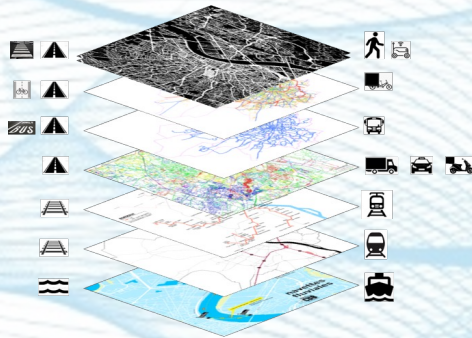


Underutilized spare capacity in **public transportation**

**Multitude of mobility options in urban areas**  
+  
**Spare capacity in public transportation**



**How to transship goods based on the joint use of public transport modes and on-demand freight modes ?**



**Different transportation modes**

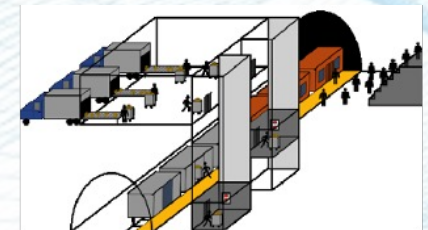
## **Synergies between Freight and People mobility**



**TRAM-FRET Pilot, Bordeaux, France, 2015.**



**Combined Passenger-Cargo, Miyazaki, Japan, since 2014.**



**Subway Delivery (Montreuil et al., 2018)**

Hyperconnected Urban Synchronodality:  
Synergies between Freight and People Mobility

6/14/23

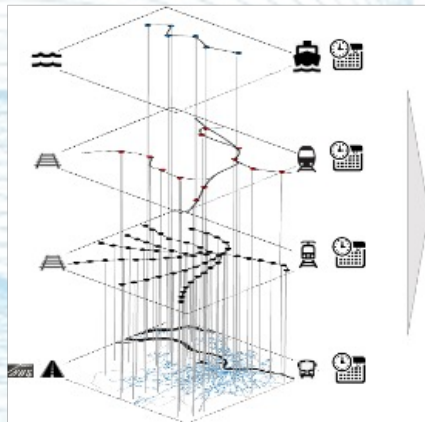
7

**IPIC 2023**

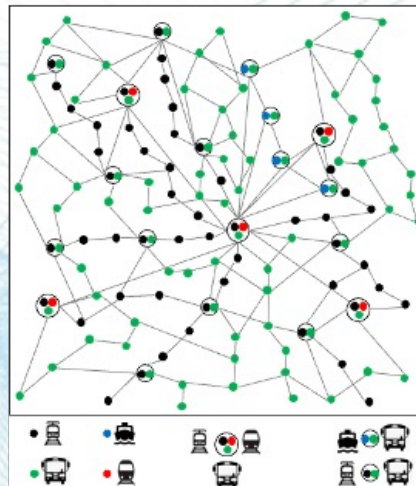
# HCL integrating people mobility networks

- Investigates the feasibility of **goods transshipment** with a joint usage of **public mobility** and **freight urban vehicles**
- Assess the **potential benefit** of a **joint mobility system** for goods delivery in urban areas

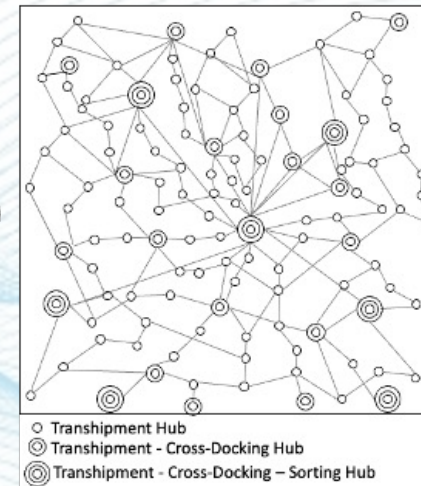
Multi-layer representation of the scheduled public transportation network



Urban area interaction network for passengers



Hyperconnected transshipment based on people mobility networks



Hyperconnected Urban Sychromodality:  
Synergies between Freight and People Mobility

6/14/23

8



# Hyperconnected Urban Sychromodality

		Freight Mobility (excluding Air)		
		Multimodality (Traffic-centered)	Intermodality (Loading units-centered)	Urban Sychromodality (Time-centered)
Network-based Hyperconnectivity	Low	# of planned freight modes = 2  Maritime-Rail OR Maritime-Road OR Rail-Road	# of planned freight modes = 2  Combined Transport <i>Road usage as short as possible</i> (Maritime-Road) OR (Rail-Road)  Co-modality <i>Optimal &amp; sustainable utilisation of resources</i> (Maritime-Rail) OR (Maritime-Road) OR (Rail-Road)	# of transportation modes =2  Planned dedicated freight mode (Maritime or Rail or Road)  On-demand freight mode (Maritime or Rail or Road)  Public transport mode (Maritime or Rail or Road)
	High	# of planned freight modes > 2  Maritime & Rail & Road	# of planned freight modes > 2  Combined Transport <i>Road usage as short as possible</i> Maritime & Rail & Road  Co-modality <i>Optimal &amp; sustainable utilisation of resources</i> Maritime & Rail & Road	# of transportation modes > 2  Planned dedicated freight mode (Maritime or Rail or Road)  On-demand freight mode (Maritime or Rail or Road)  Public transport mode (Maritime or Rail or Road)

# Multimodal on-demand transshipment

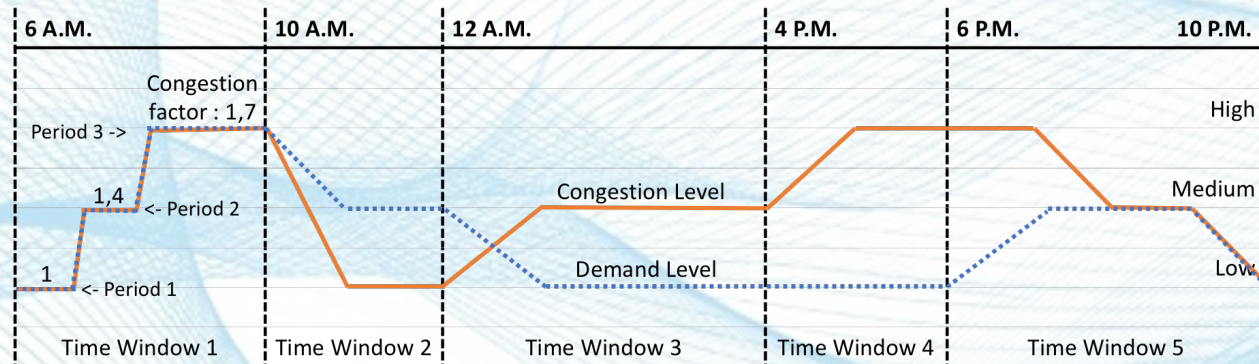
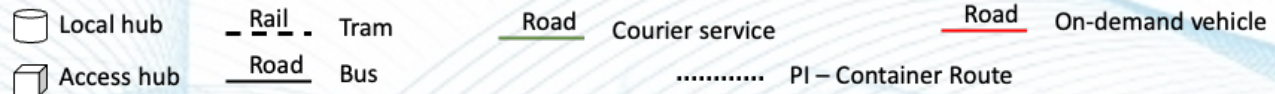
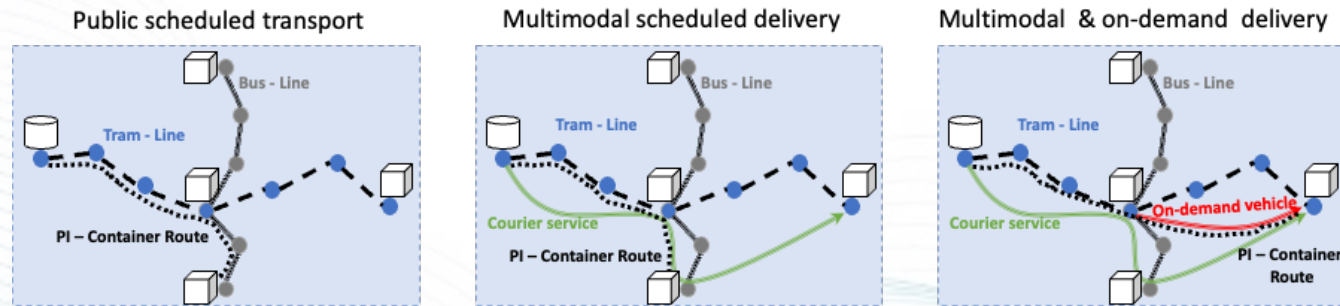
Multiple **transportation options** for each PI - Container

**More possibilities** to satisfy due dates

Travel-time based on **transport mode** and **congestion factor**

**Capacity** of each transportation mode **vary during the day**

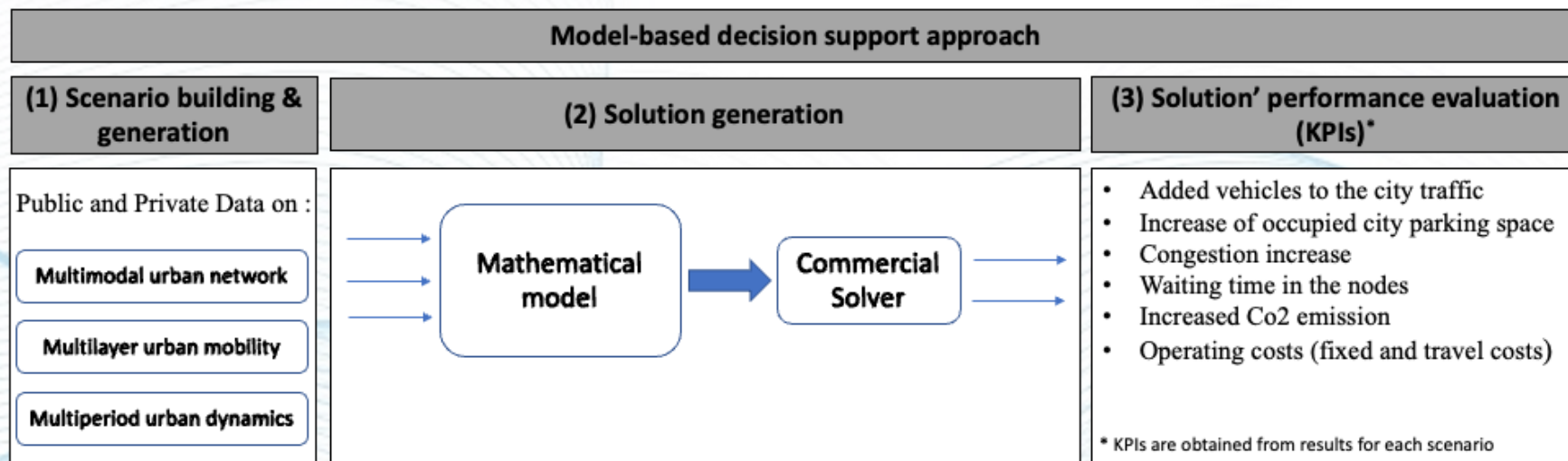
**Capacity** decrease with the increase of **congestion level**.





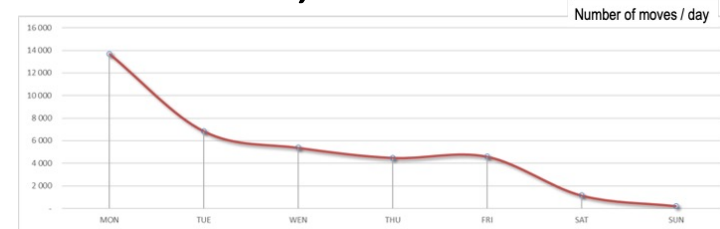
# Three-phase decision support approach

Minimize the impact of **containers' journey** in the **time** and **space** of urban transport network.



The objective considered in this **planning problem** is to commit to a **high service level** (all requests delivered before the due date) with the **minimum urban footprint**.

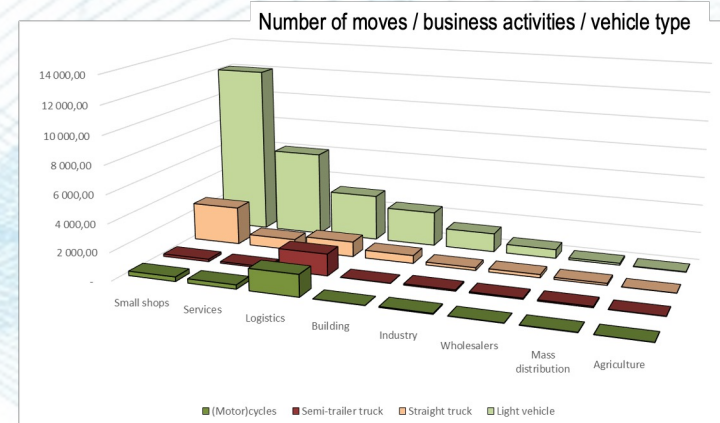
# Typical urban context : Bordeaux, France



Observation unit : receiving, shipping or joint operation **using a motor vehicle**, so-called “move”.

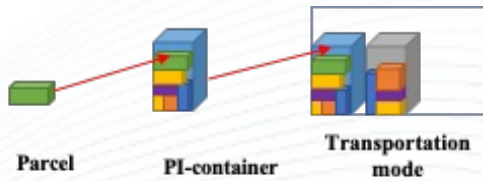
The number of movements is based on **a typical 7-day week** \*.

\* postal and hospital flows, rubbish collections are excluded from the scope of the survey

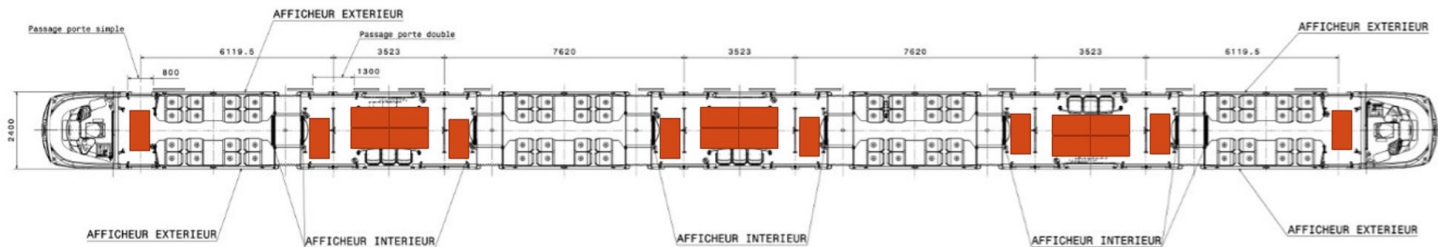




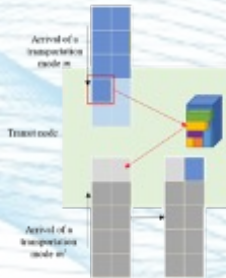
# Urban Parcel Delivery considering tramway



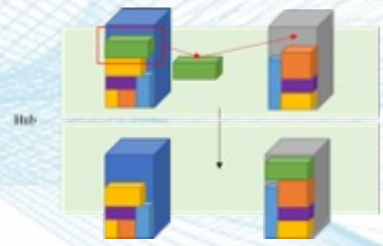
Parcel container,  
Source : project-mo.de, 2020.



- **Transshipment** : Moving a container from a mode  $m$  to a mode  $m'$



- **Reload** : Moving a parcel from a container  $Q$  to another container  $Q'$



# Toward a hyperconnected logistic network

- Emphasizing the interconnected utilization of existing urban logistics **facilities** and usable **spaces**

## MOBILE



Micro-depots UPS, Hamburg, Germany, 2012.



Mobile depot TNT Express, Brussels, Belgium, 2013.



CubiVan, City-Hub, Source : DHL Group, Germany, 2017.



City-Hub Rytte, Source : Krone Group, Germany, 2018.



EZ-PRO Renault & DPDgroup scenarios, 2018.

## STATIONARY



Micro-platform project, Bordeaux, France, 2003.



Micro-platform project, Barcelona, Spain, 2014.



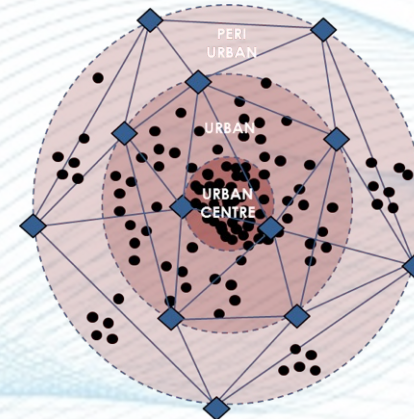
KoMoDo project, open micro hub, Berlin, Germany, 2018.



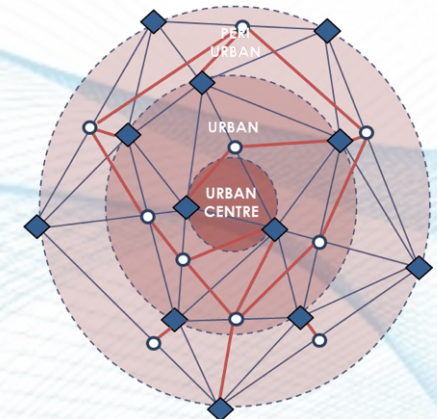
Micro depot in public spaces, source : DPD, Germany, 2019.



Micro-hub, Paketin GmbH, 2020.



◆ Distribution Centers / Small-sized Warehouses  
● Final destinations



○ Transshipment Hubs  
— Alternatives ways

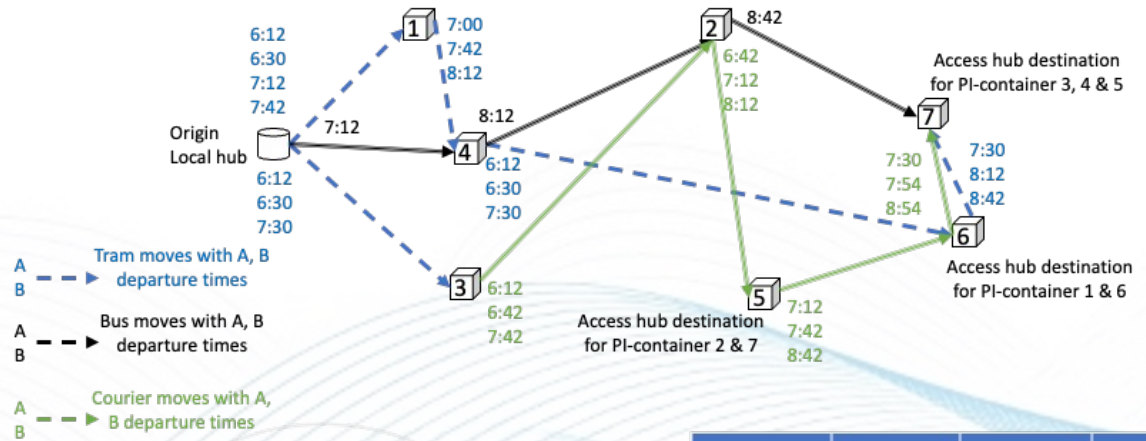


# Scheduled multimodal delivery service

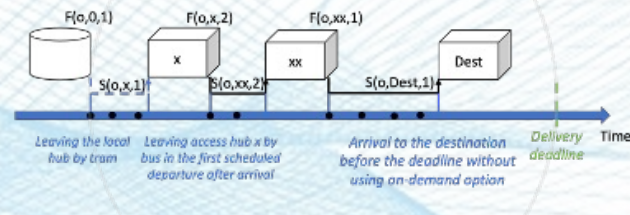
Scheduled public and private routes connect hubs.

Public transport : tram and bus

	Period		
	1	2	3
1	6:00		
2	6:12		
3	6:30		
4	6:42		
5	7:00		
6		7:12	
7		7:30	
8		7:42	
9		7:48	
10		7:54	
11			8:12
12			8:30
13			8:42
14			8:54



- Local hub
- Access hub
- Travelling by tram
- Travelling by bus
- $S(o,i,k)$  Arrival of PI-container  $o$  to hub  $i$  by vehicle type  $k$
- $F(o,i,k)$  Departure of PI-container  $o$  from hub  $i$  by vehicle type  $k$
- Scheduled move



PI -Container	Access hub destination	Delivery due time	Arrival time to the destination node
1	6	7:00	7:24
2	5	9:00	7:36
3	7	8:00	7:48
4	7	8:00	7:48
5	7	9:00	7:54
6	6	8:00	7:24
7	5	7:00	7:36

# Delivery plans of 30 PI-containers

Truck n°1									
			Actual delivery time						
			Due date		Multimodal & on-demand		VRP		
Nb Order	Origin	Destination	min	sec	min	sec	min	sec	
1	1	2	119	7140	102,20	6 132	3,28	197	
7	1	2	119	7140	102,20	6 132	3,28	197	
8	1	2	92	5520	87,20	5 232	3,28	197	
16	1	2	75	4500	73,20	4 392	3,28	197	
3	1	3	66	3960	62,00	3 720	11,82	709	
4	1	4	77	4620	77,00	4 620	21,07	1264	
9	1	4	118	7080	105,80	6 348	21,07	1264	
27	1	4	110	6600	103,00	6 180	21,07	1264	
12	1	5	74	4440	73,20	4 392	29,80	1788	
13	1	5	48	2880	45,20	2 712	29,80	1788	
26	1	5	100	6000	99,50	5 970	29,80	1788	
5	1	9	42	2520	40,20	2 412	71,00	4260	
6	1	9	71	4260	70,50	4 230	71,00	4260	
11	1	9	56	3360	54,20	3 252	71,00	4260	
19	1	8	80	4800	76,50	4 590	80,02	4801	
20	1	8	76	4560	67,50	4 050	80,02	4801	
30	1	8	105	6300	86,50	5 190	80,02	4801	

Truck n°2									
			Actual delivery time						
			Due date		Multimodal & on-demand		VRP		
Nb Order	Origin	Destination	min	sec	min	sec	min	sec	
17	1	12	83	4980	69,80	4 188	4,58	275	
21	1	12	92	5520	89,00	5 340	4,58	275	
23	1	12	55	3300	43,20	2 592	4,58	275	
14	1	10	64	3840	62,80	3 768	41,80	2508	
28	1	11	97	5820	96,00	5 760	50,05	3003	
15	1	13	87	5220	83,00	4 980	59,83	3590	
18	1	13	71	4260	69,00	4 140	59,83	3590	
25	1	13	88	5280	83,00	4 980	59,83	3590	
29	1	13	105	6300	98,00	5 880	59,83	3590	
2	1	7	54	3240	52,20	3 132	69,37	4162	
24	1	7	86	5160	80,80	4 848	69,37	4162	
10	1	6	78	4680	77,20	4 632	78,00	4680	
22	1	6	76	4560	63,50	3 810	78,00	4680	

VRP approach : **total distance traveled** of 13.04 km.

VRP approach : **vehicle utilization rate decreases** after each visit to the access hubs.

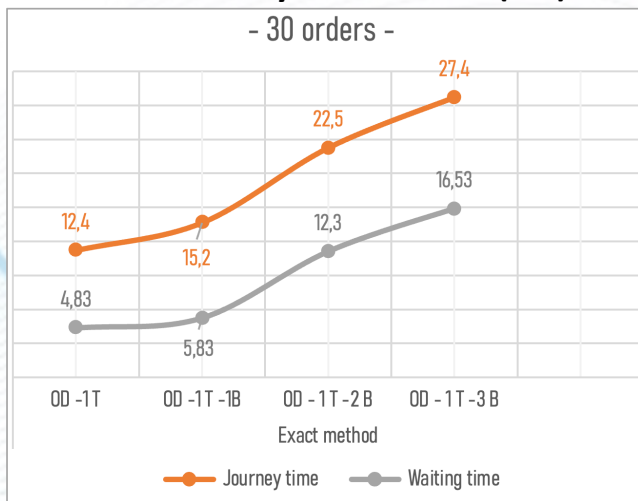
Multimodal & on-demand solution :  
29 PI-Containers used **only public transport (bus and tram lines)**

One PI-container used **on-demand transport by cargo bike.**

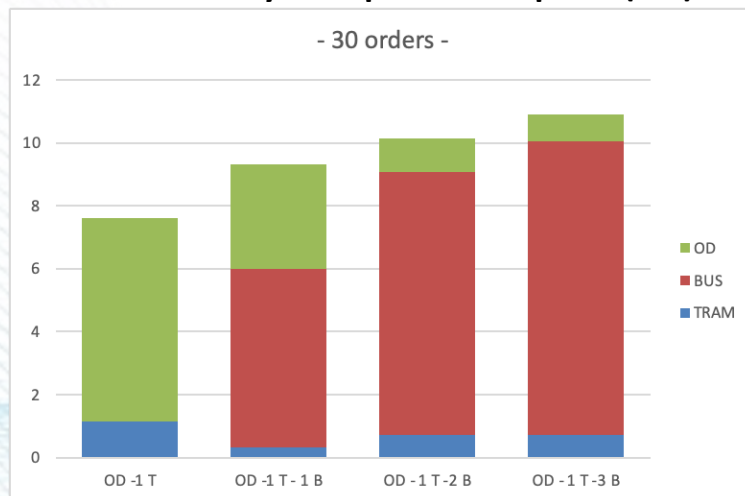


# Impacts of network connectivity

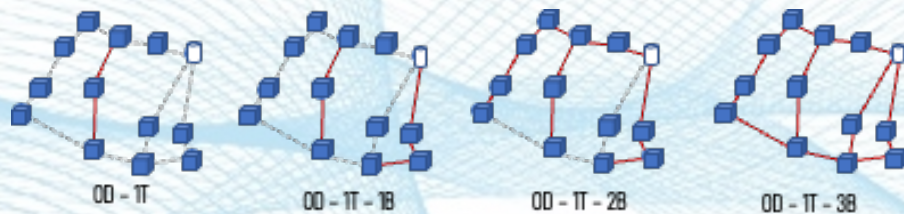
Mean Time by PI-Container (mn)



Mean Time by transportation option (mn)



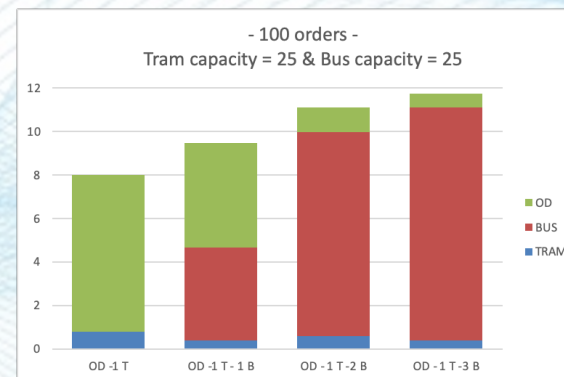
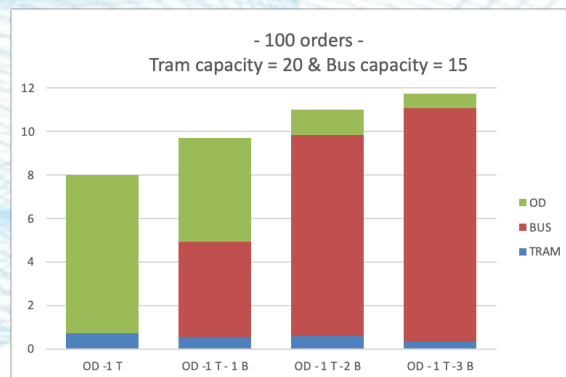
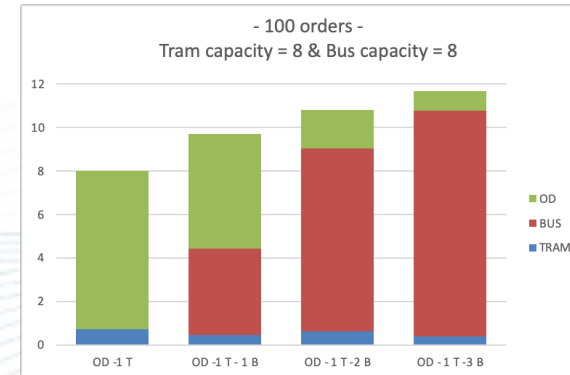
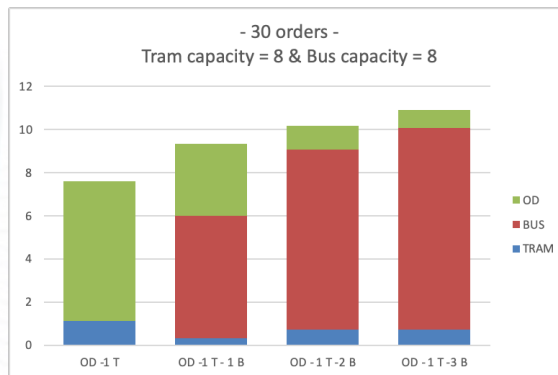
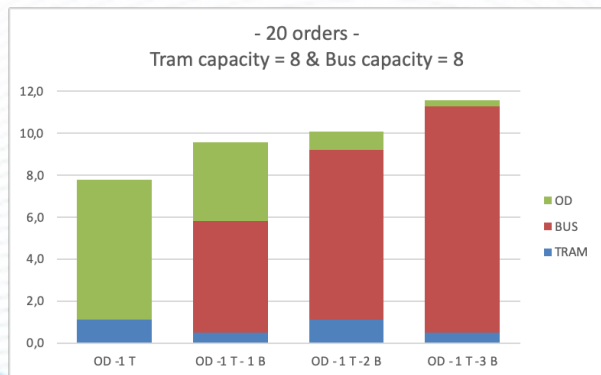
Nbre of moves with on-demand vehicles



- Local Hub
- Access Hub
- OD : On-Demand
- 1T : One Tram line
- 1B : One Bus line
- 2B : Two Bus lines
- 3B : Three Bus lines

# Impact of transport capacity

Mean Time by transportation option (mn)





# Conclusions and perspectives

- New approach for urban freight **transshipment** based on joint use of **on-demand mode** and **public transport**
- The role of synchromodality **reducing parcels footprint** and congestion levels
- Creating **synergies between freight and people mobility** in urban areas demonstrates benefits from the economic, ecologic, and societal perspectives
- Extending the model to consider several local hubs, **more vehicle types/services** in an on-demand mode
- Extending the set **transport options** in the mobility network



# IPIC 2023

## 9th International Physical Internet Conference

June 13-15, 2023  
Athens, Greece



Thanks !

Ευχαριστώ !

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Expanding the logistics Scope