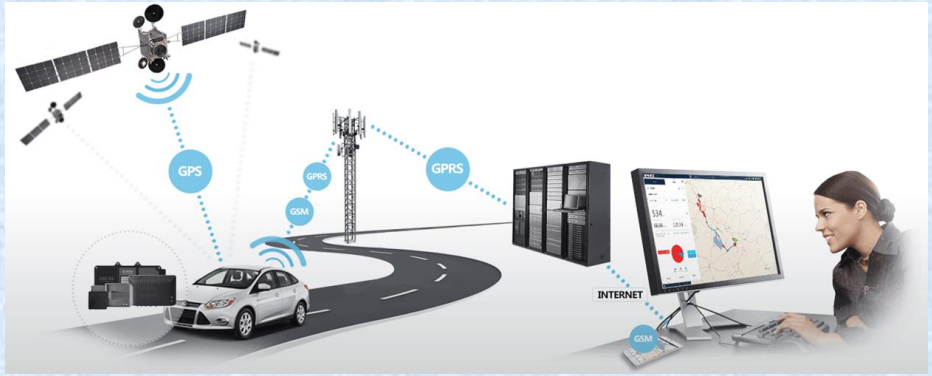
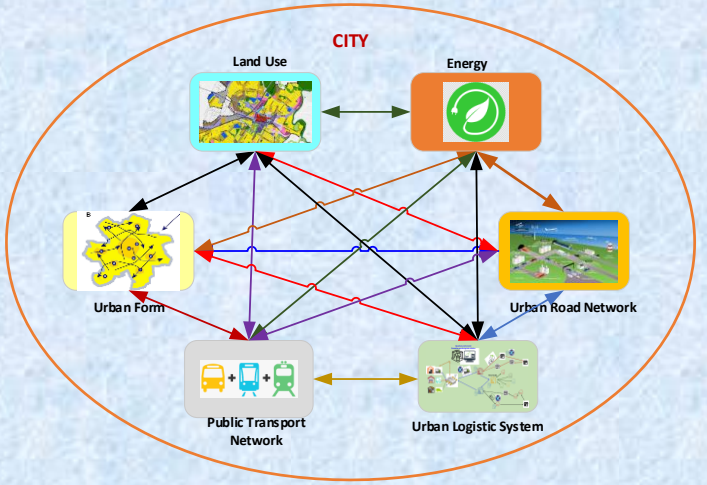
QUINES EINES I DADES DISPOSEM PER UNA DISTRIBUCIÓ URBANA DE MERCADERIES (DUM) EN UN SISTEMA COMPLEX COM LA CIUTAT?





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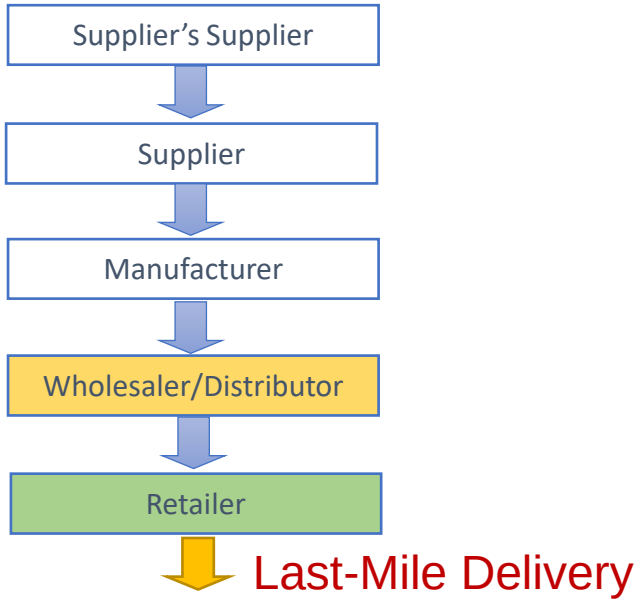
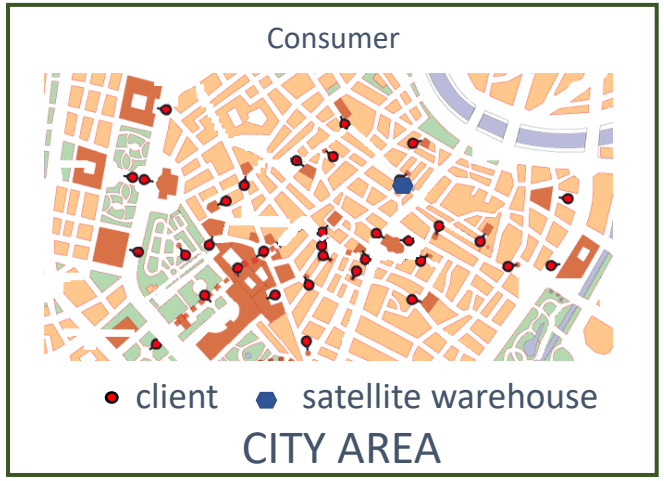
Universitat Politècnica de Catalunya
UPC-Barcelona TECH

COMENTARIS INTRODUCTORIS

DISTRIBUCIÓ URBANA DE MERCADERIES (LAST-MILE DELIVERY)

CADENA DE SUBMINISTRAMENT



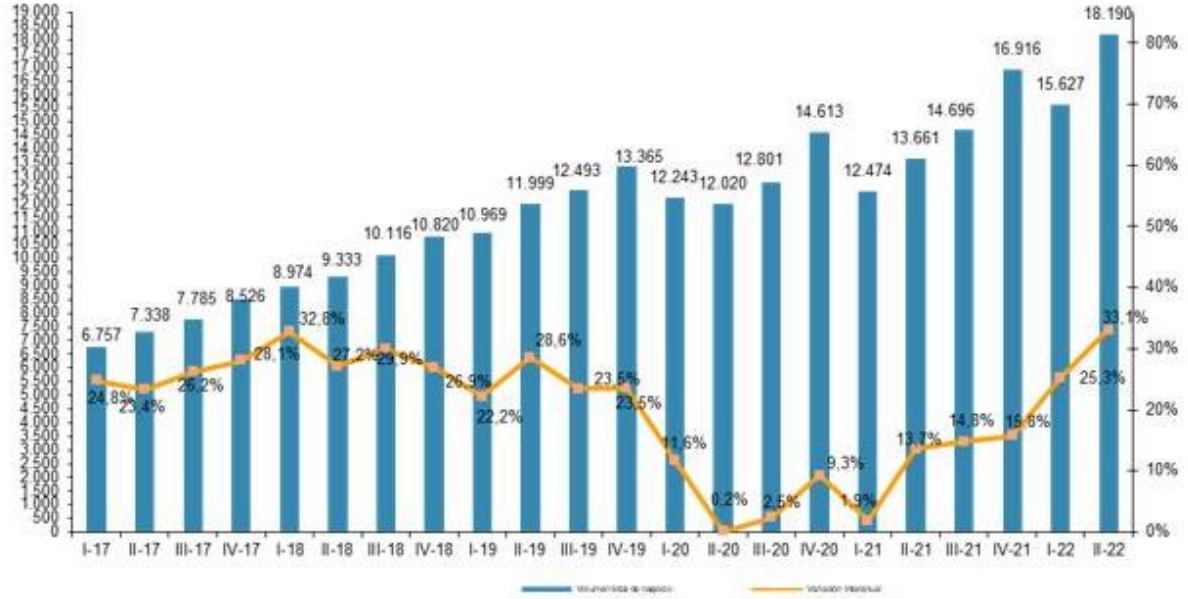


Last-mile delivery, the last step in the supply chain, describes the movement of goods from a ***warehouse, consolidation centre, transportation hub or similar****, to a final delivery destination, facing the challenge of making the deliveries in urban areas*

Source: Citylogistics urban goods Distribution and last mile delivery and collection

EL CREIXEMENT DEL COMERÇ ELECTRÒNIC

EVOLUCIÓN TRIMESTRAL DEL VOLUMEN DE NEGOCIO DEL COMERCIO ELECTRÓNICO Y VARIACIÓN INTERANUAL (millones de euros y porcentaje)



Fuente: CNMC

LAS DIEZ RAMAS DE ACTIVIDAD CON MAYOR PORCENTAJE DE VOLUMEN DE NEGOCIO DEL COMERCIO ELECTRÓNICO (II-22, porcentaje)

Fuente: CNMC

EL PROBLEMA CREIXENT DE LA DISTRIBUCIÓ DE L'ÚLTIMA MILLA

EXPERIÈNCIES INICIALS SOBRE EINES I DADES

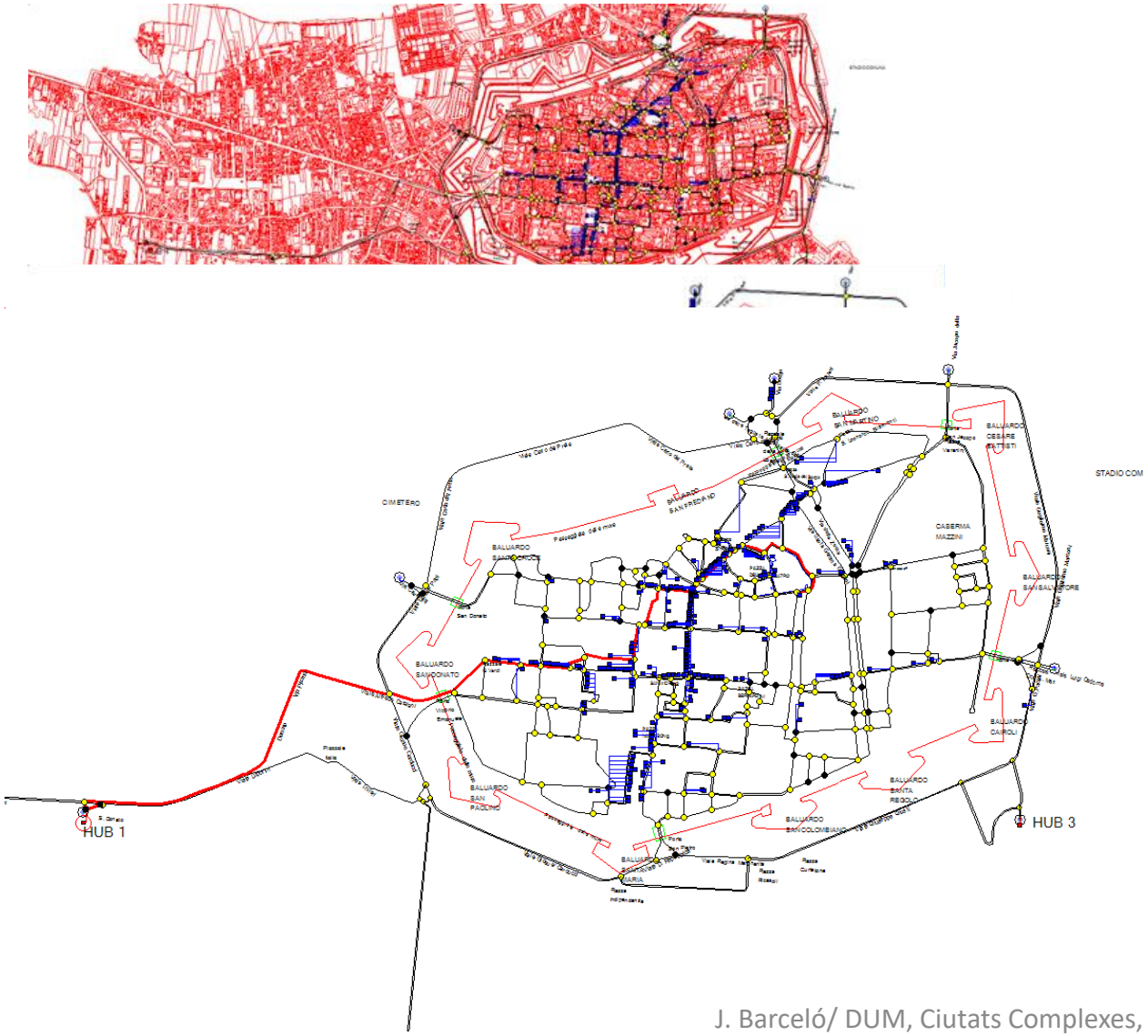
Els projectes europeus del Programa INTERREG

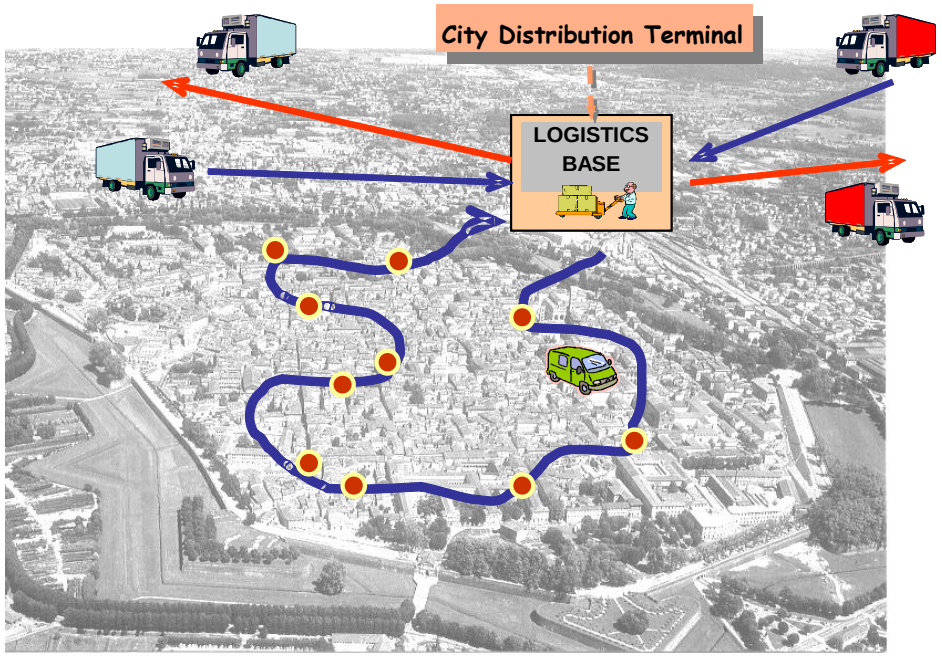
- MEROPE (INTERREG-III MEDOC, Axe 3, Mesure 4, CODE: 2002-02-3.4-I-091) Development of a Decision Support System for the Design and Evaluation of City Logistics applications. January 2003-December 2004.
- MATAARI (INTERREG-IIIB MEDOCC, Axe 3, Mesure 1, CODE 2004-04-3.1-I-113) Improvement of Accessibility to Transport and Logistic Services among Urban Areas and Intermodal Centres. January 2005-December 2007.

CIUTATS PILOT: LUCCA, PIACENZA/OBJECTIUS DELS PROJECTES

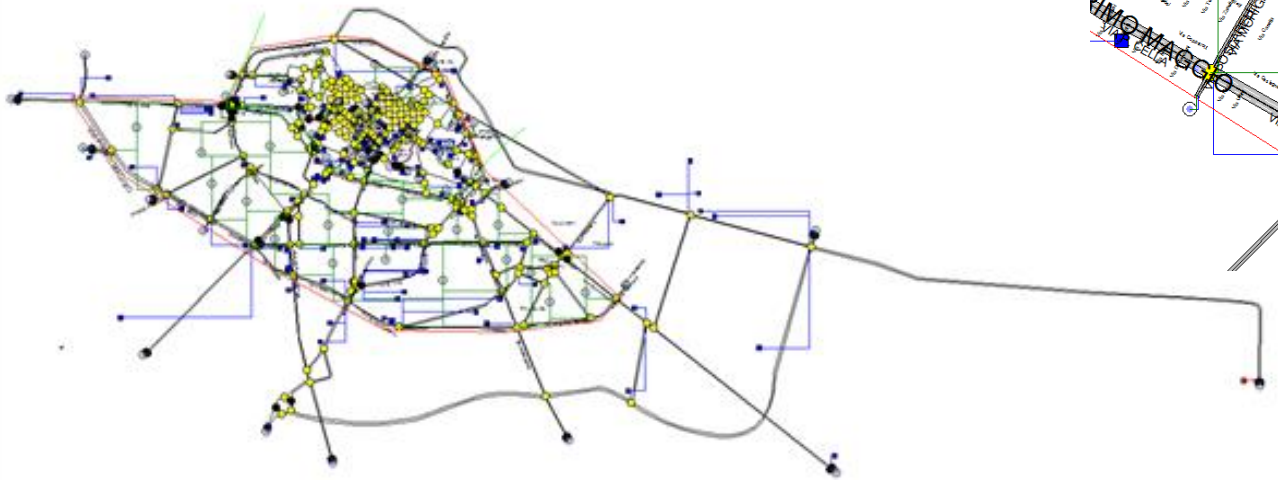
- Restriccions i regulacions de la distribució urbana de mercaderies
  - Restriccions d'accés, identificacions de punts de càrrega/descàrrega, mecanismes de reserva, finestres temporals...
- Utilització de flotes netes: vehicles elèctrics ad hoc
- Cooperació entre operadors logístics: transbordaments, consolidacions de càrregues als Centres de Distribució Urbana de Mercaderies
- Esquemes innovadors de distribució B2C: distribució HORECA, utilització d'aparcaments, satèl·lits (freight transit points)
- Serveis 3PL
- Plantejament Metodològic:
  - Utilització de Models: decisions sobre el tipus i abast dels models
  - Identificació de les dades necessàries pels models
  - Definició dels processos de recollida de dades
    - Mapa digital de la ciutat → Graf de la xarxa viària
    - Localitzacions dels clients, demandes del clients, tipologies...
    - Localitzacions potencials dels punts de càrrega/descàrrega
    - Localitzacions potencials del Centres de Distribució Urbana de Mercaderies

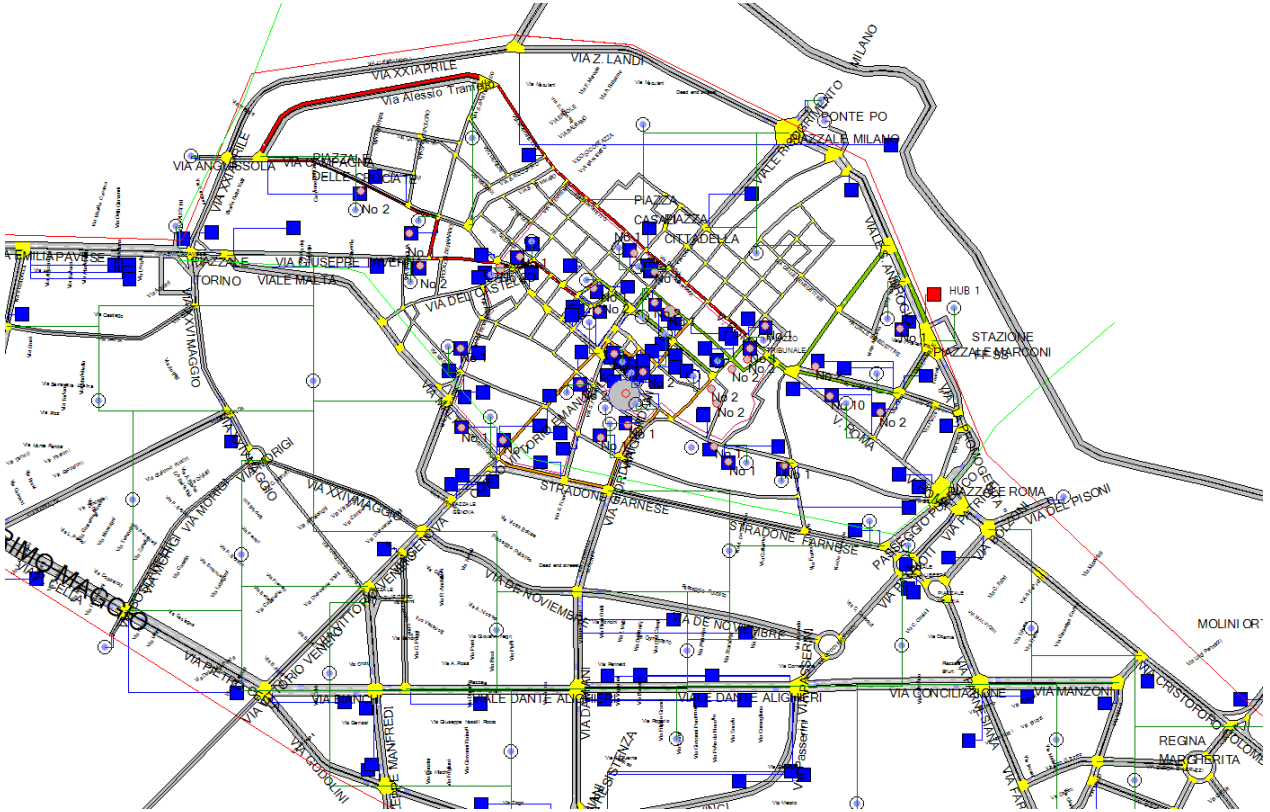
EL CAS DE LUCCA: MODEL, ESCENARIS, DECISIONS



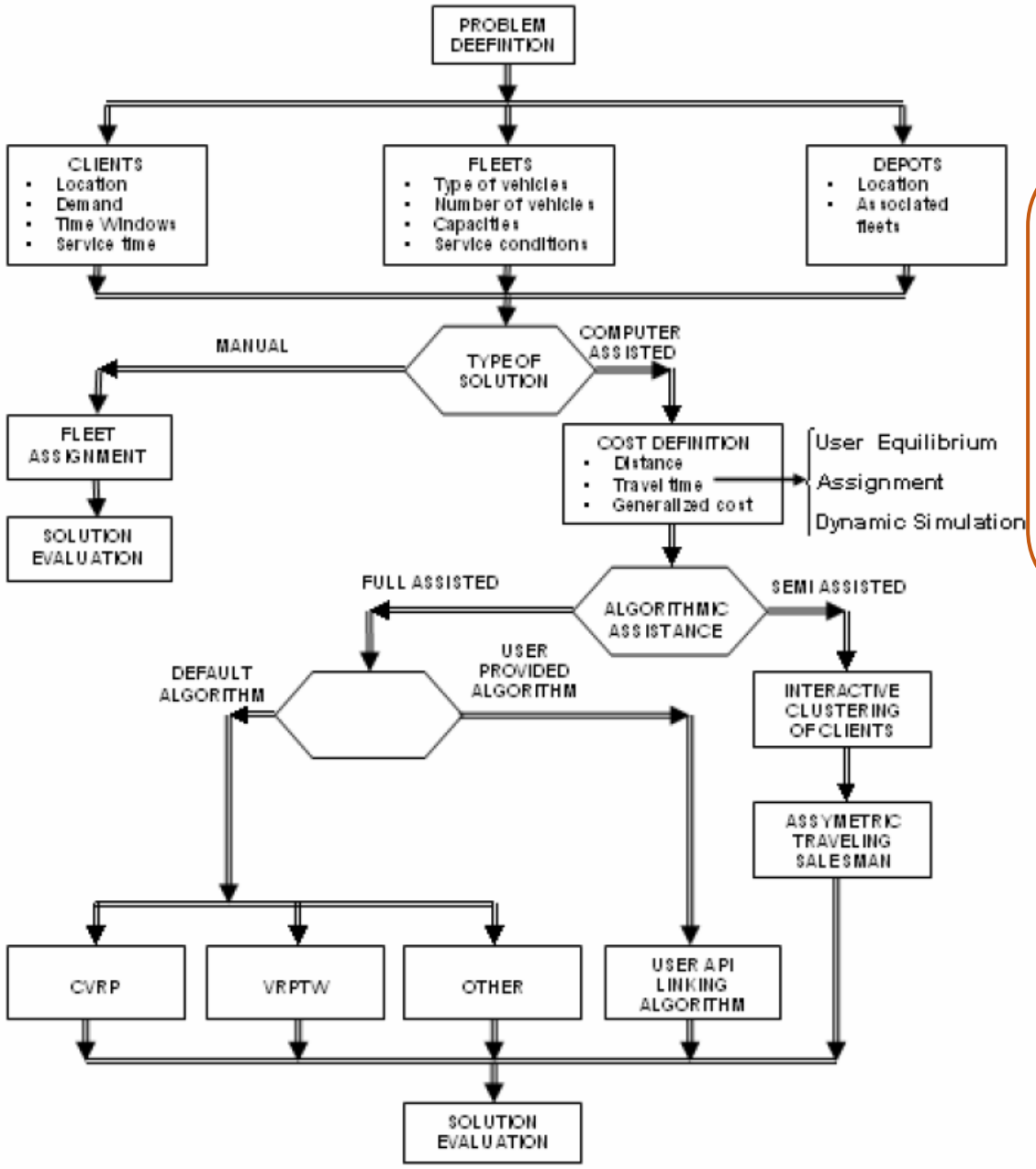


EL CAS DE PIACENZA





ARQUITECTURA DEL SUPPORT MODELISTIC: EINES I DADES



Un model **organitza estructuradament** el que sabem (o creiem saber) sobre un sistema per a poder **entendre com es comporta** en el present i **com es pot comportar** en el futur si canvien les circumstàncies. Els models són especialment útils quan els experiments directes, controlats, són difícils o impossibles de realitzar, com passa amb els sistemes de transport

Hipòtesis: ***Les dades contenen informació sobre el fenomen que les genera***

El processament de les dades: ***Té com objectiu trobar aquesta informació***

Les dades per si mateixes no són informació hi ha que extreure-la mitjançant el tractament adient

DATA WITHOUT MODELS ARE JUST NUMBERS
MODELS WITHOUT DATA ARE JUST STORIES

ELS MODELS TRADUEIXEN FORMALMENT EL CONEIXEMENT QUE TENIM D'UN SISTEMA. UNA ULLADA A ALGUNS DELS ELEMENTS CLAU DEL SISTEMA LOGÍSTIC URBÀ.

DISTRIBUCIÓ URBANA DE MERCADERIES: STAKEHOLDERS I INTERACCIONS

Operadors de Transport
Flotes & Conductors

Clients & Punts de
Lliurament i Recollida

Condicions de Subministrament & Contractes

- **Routing & Scheduling de la Flota**
- **Temps i condicions de servei**
- **Finestres temporals de servei**

Regulacions del Subministrament

- **Restriccions d'accés a les zones urbanes**
- **Sistemes de control d'accessos**
- **Regulacions de Càrrega/Descarrega**
- **Punts de Càrrega/Descarrega**
- **Regulacions sobre vehicles**
- **Polítiques mediambientals**

Regulacions del Subministrament

Administració Local

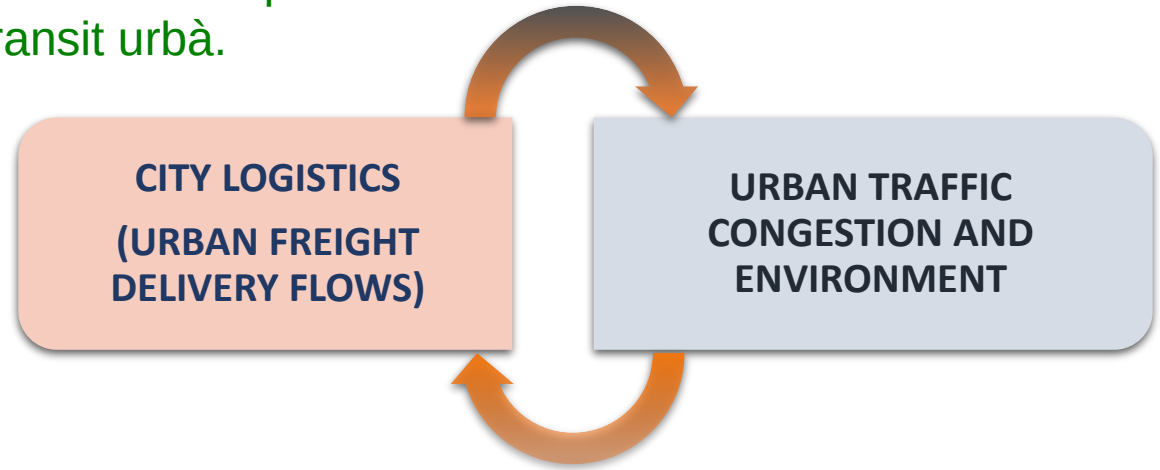
CARACTERÍSTIQUES DE LA DISTRIBUCIÓ URBANA DE MERCADERIES

"City Logistics models must account for two way interaction ".

Regan, Mahmassani, Jaillet., 1998

Les activitats DUM tenen un impacte sobre la congestió del trànsit (CV→ 15%-20% del volum del transit a les hores punta ~ 60% dels lliuraments al detall abans de les 11:00am en moltes ciutats)

⇒ necessitat d'incloure els impactes de la DUM I les flotes de vehicles comercials en les estimacions del transit urbà.



Les activitats DUM estan afectades per la congestió del trànsit

⇒ les constriccions sobre les operacions per als enrutaments i els models d'optimització que han de prendre en consideració les variacions temporals de les congestions de trànsit i llurs impactes sobre els temps de recorregut.

MODELS, TIPUS DE DECISIONS I DADES AL CAS DUM

DECISIONS TO DESIGN AND MANAGE LAST-MILE DELIVERY SYSTEMS

THREE MAIN CHALLENGES OF LAST-MILE DELIVERIES

- IMPROVE PERFORMANCE AND QUALITY
- IMPROVE OPERATIONAL PERFORMANCE
- OPTIMIZE SERVICE LEVELS

DECISIONS

- **STRATEGIC** → LONG TERM → DESIGN OF THE SYSTEM
- **TACTICAL** → EFFICIENT USE OF RESOURCES
- **OPERATIONAL** → SHORT TERM DAY-TO-DAY AND DAILY OPERATIONS
- **REAL-TIME** → MANAGEMENT DECISIONS TO REACT ON DISCREPANCIES BETWEEN PLANNED AN EXECUTED

Examples of:

- Strategic decisions:
  - System's structure: Single Echelon, 2 Echelon,…
  - Location of warehouses (CDC)
  - Location of urban depots (Satellites)
- Tactical decisions:
  - Typically involve decisions about how to effectively and efficiently use the existing infrastructure and how to organize operations according to strategic objectives
- Operational decisions:
  - Load acceptance
  - Assignment of drivers to vehicles
  - Dispatching and scheduling of services
- Real-Time Decisions:
  - System monitoring, tracking vehicles, orders, conditions
  - Dynamic rerouting

DECISION SUPPORT SYSTEM

MODELS: LOCATION-ROUTING ROUTING…

DATA COLLECTION & DATA ANALYTICS

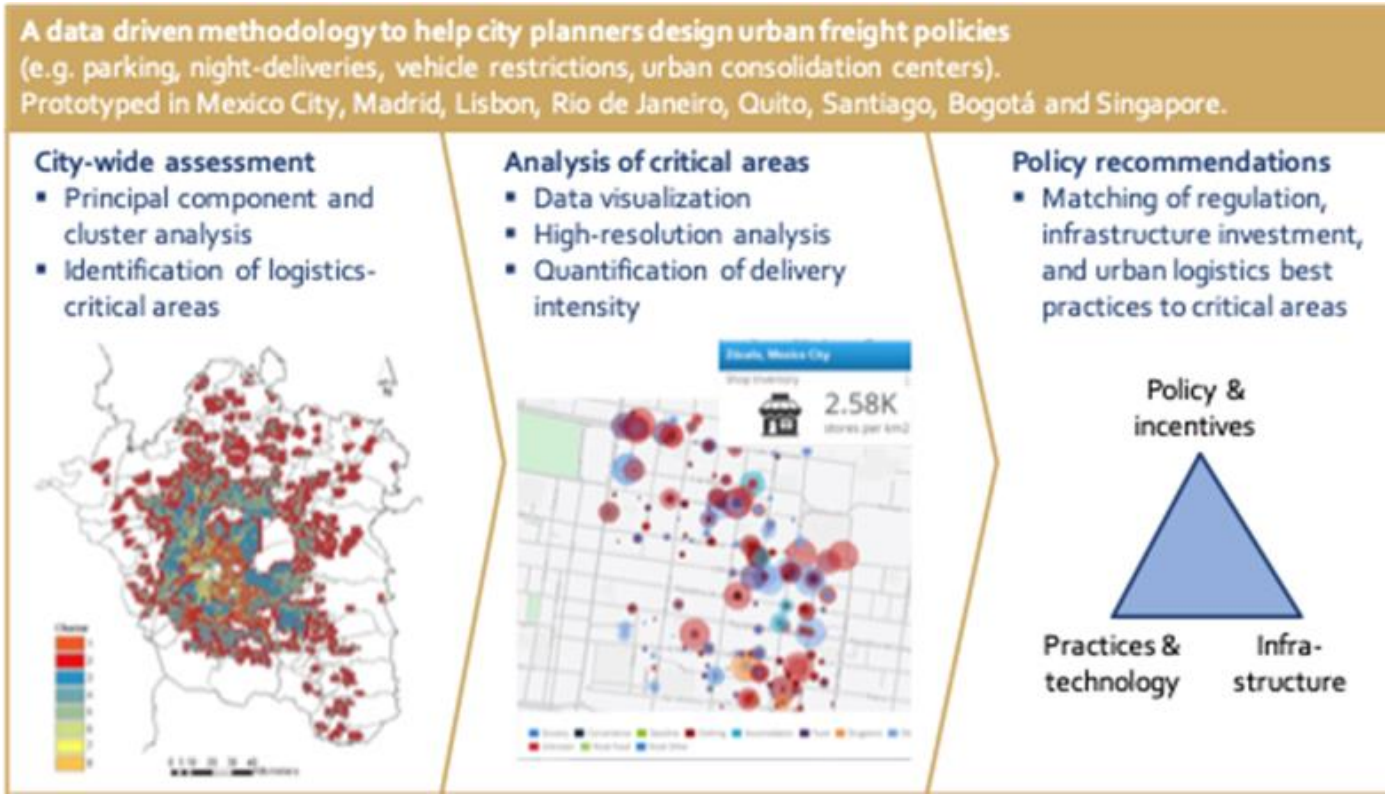
A. Goel, Fleet.Telematics: Real-Time Management and Planning of Commercial Vehicle Operations, Springer

MIT Megacity Logistics Lab

MIT Center for Transportation & Logistics

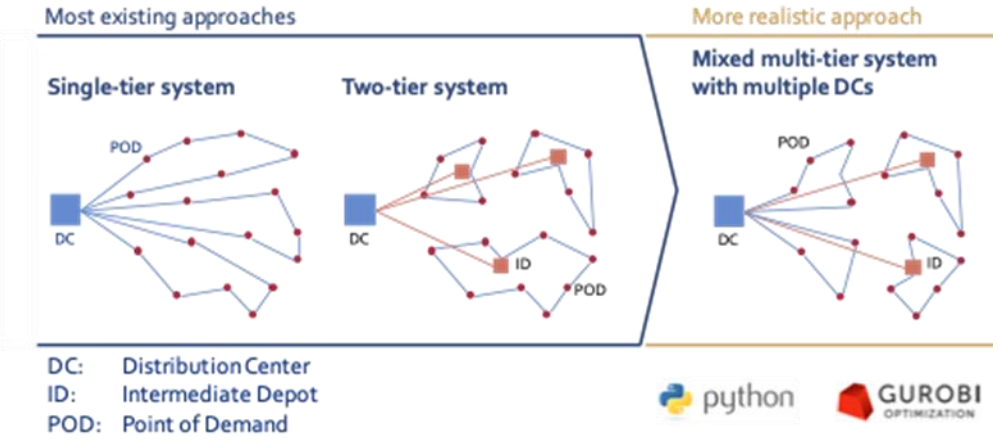
Designing urban logistics operations requires in-depth understanding of consumers and channels combined with high-resolution, data-driven modeling.

Urban Logistics Toolkit and Best Practices



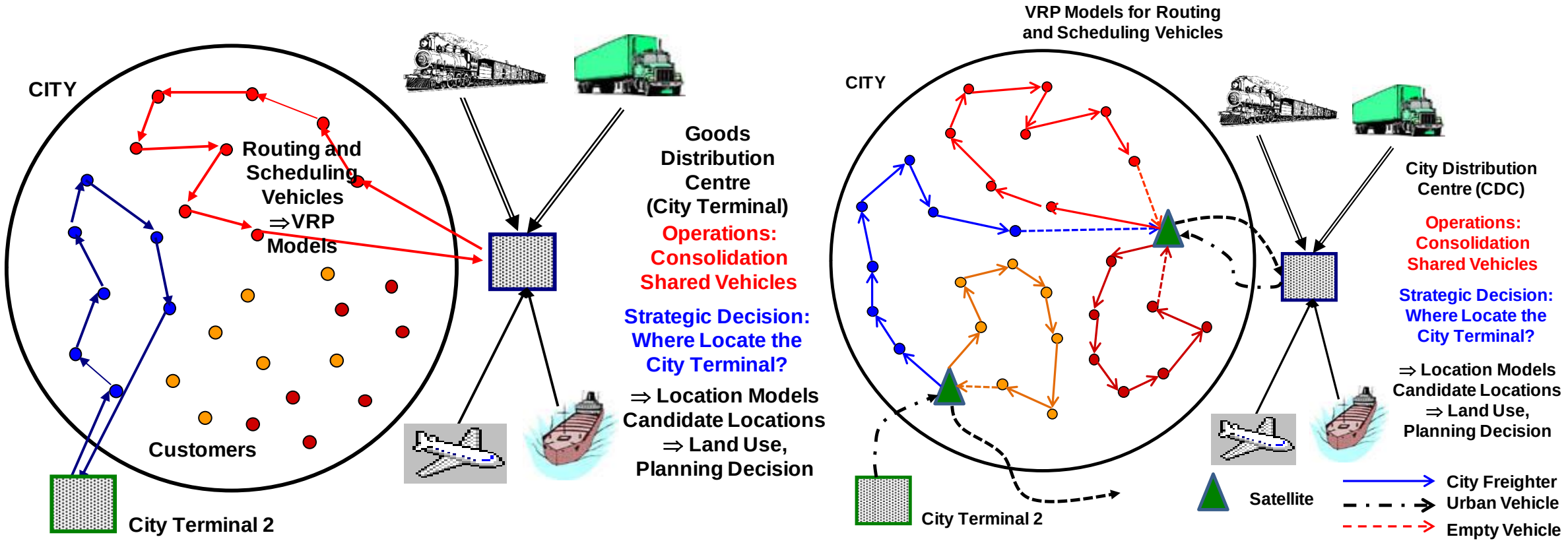
- On-going efforts from cities to invest in public transportation, limiting road access and parking spaces in favor of pedestrian and public transit infrastructure, disproportionally impact logistics operations.
- Since urban freight also generates an important share of congestion, pollution and other negative externalities, city logistics activities are always under pressure from regulatory actions.
- Companies collect tens of thousands of data points every day from a variety of systems and sensors in their logistics operations

Urban Distribution Network Design



Font: https://megacitylab.mit.edu/

EXAMPLE OF STRATEGIC DECISIONS: SYSTEM DESIGN CDC, ONE-ECHELON(TIER), OR TWO-ECHELON(TIER), FREIGHT DISTRIBUTION SYSTEMS AND SATELLITE LOCATIONS



2-ECHELON: City freighters (CIVITAS PROJECTS) LA PETITE REINE (PARIS) TNT TRIAL (BRUSSELS)

First generation: 400 litres

Capacity load: 80 kg

Second generation: 400 litres

Capacity load: 150kg

Third generation: 1,400 litres

Capacity load: 180kg

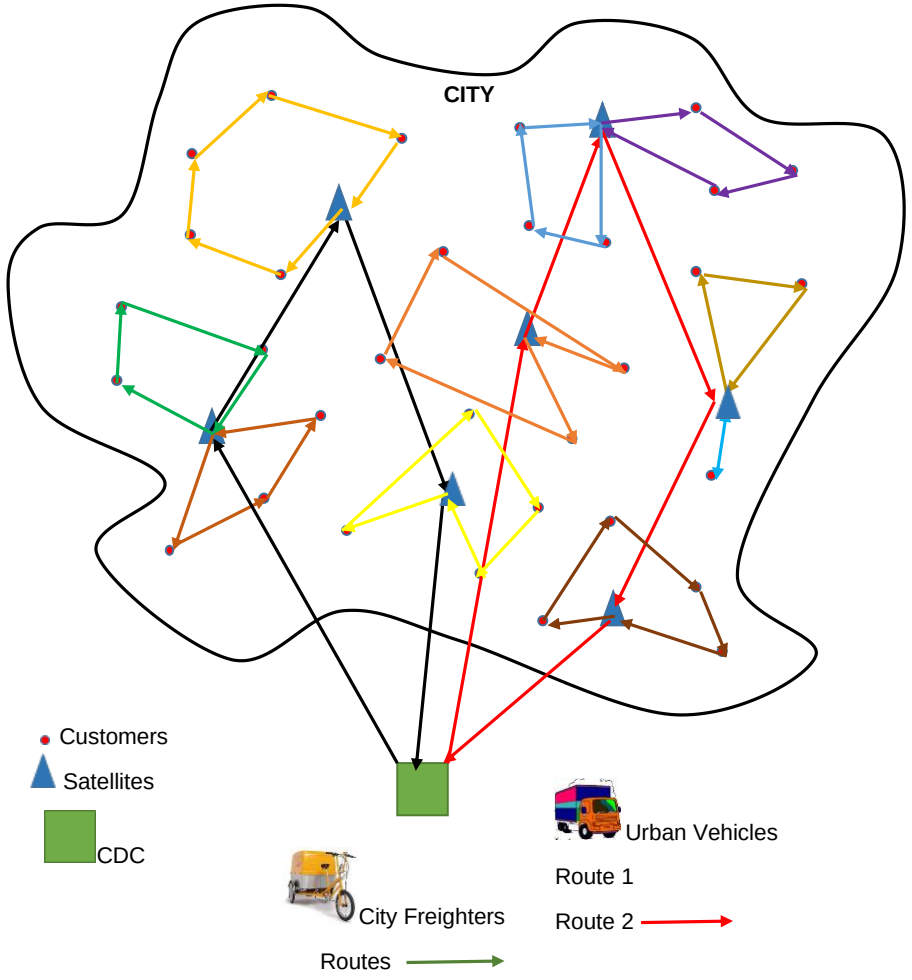
Speed: 20 km/h

Length: 2.50m

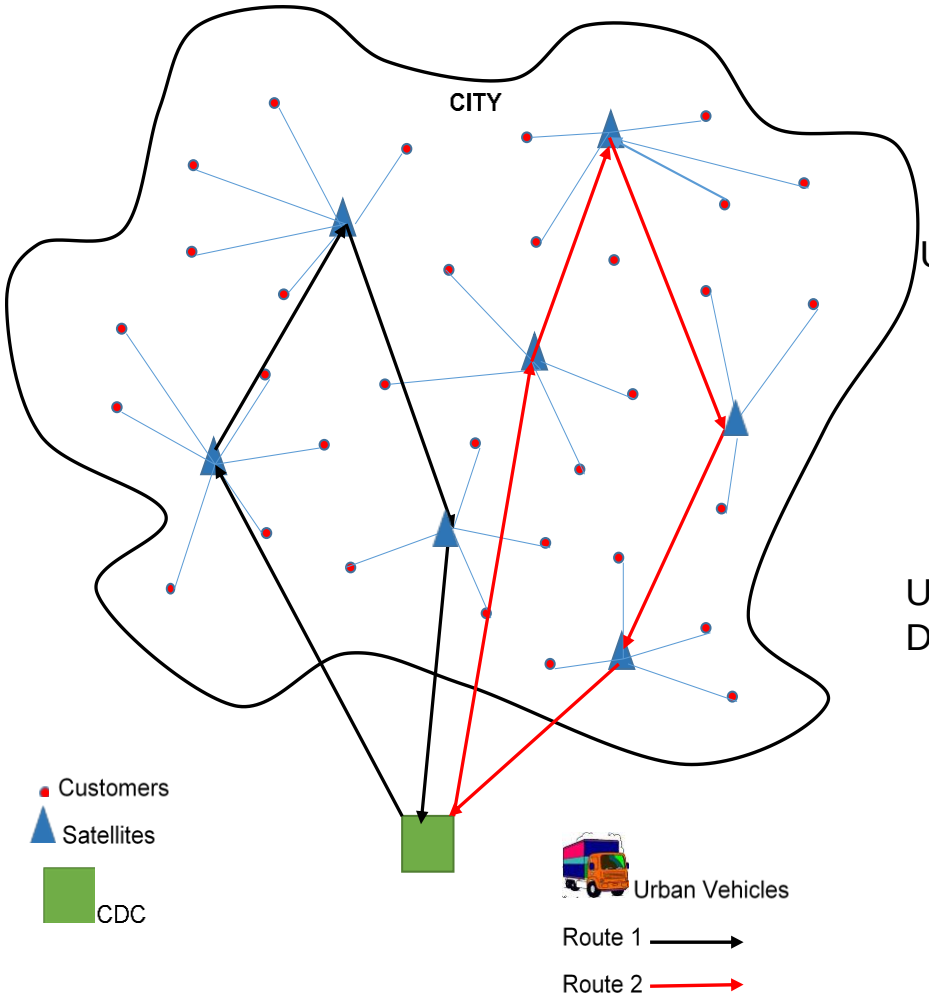
Trailer/truck fitted with typical depot facilities

- Mobile depot is loaded daily with all the deliveries bound for the inner-city
- It is driven to a central location

- .From there, electrically supported tricycles carry out the last-mile delivery operation.



LAST MILE DELIVERIES: CUSTOMER COLLECTION POINTS



Urban Pickup Location

Urban Freight Station: DHL Packstation

Amazon Parcel Pick Up Locker

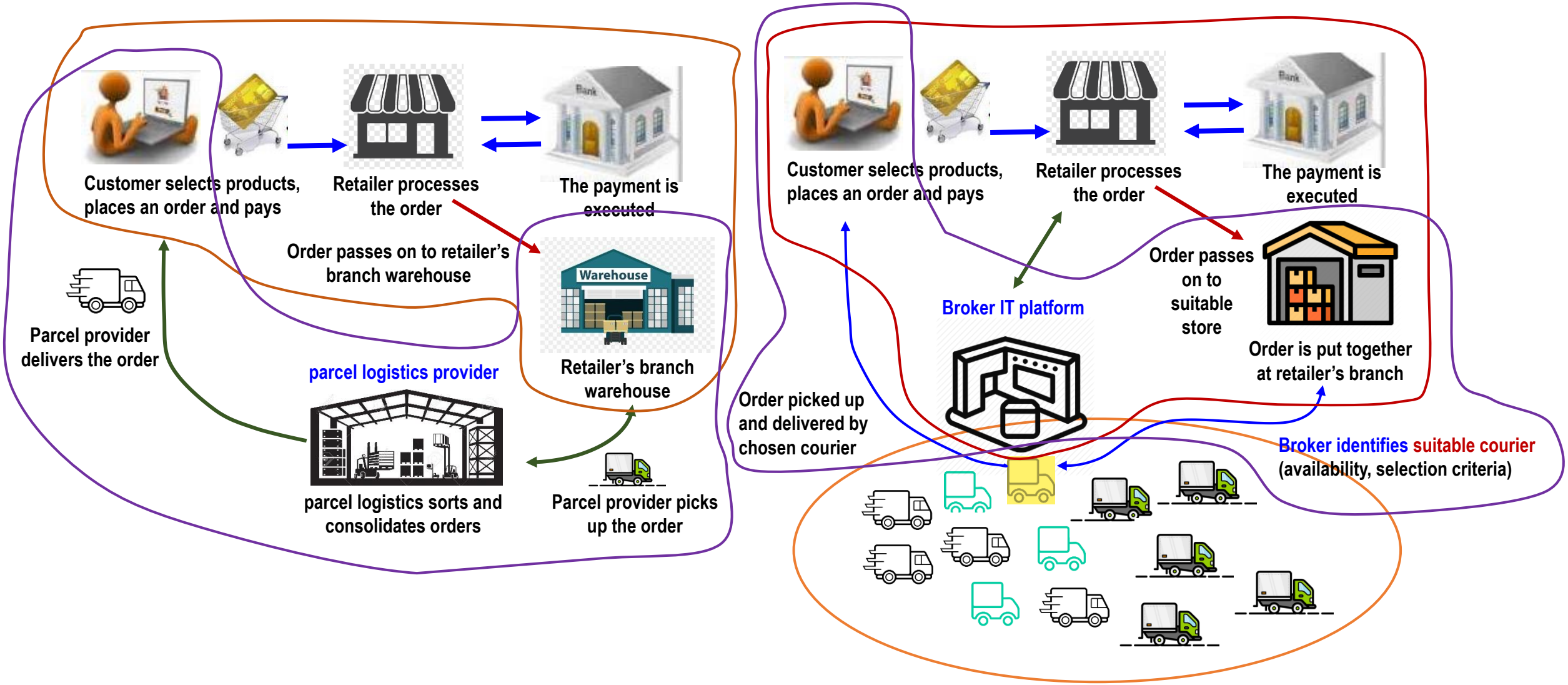
Alternative solution for home deliveries. Locker boxes have been installed in public spaces (e.g. main station, market place etc.), but also at parking places of big companies.

Avoiding unnecessary trips of DHL-delivery vehicles, give the customers free choice of picking the parcels up.

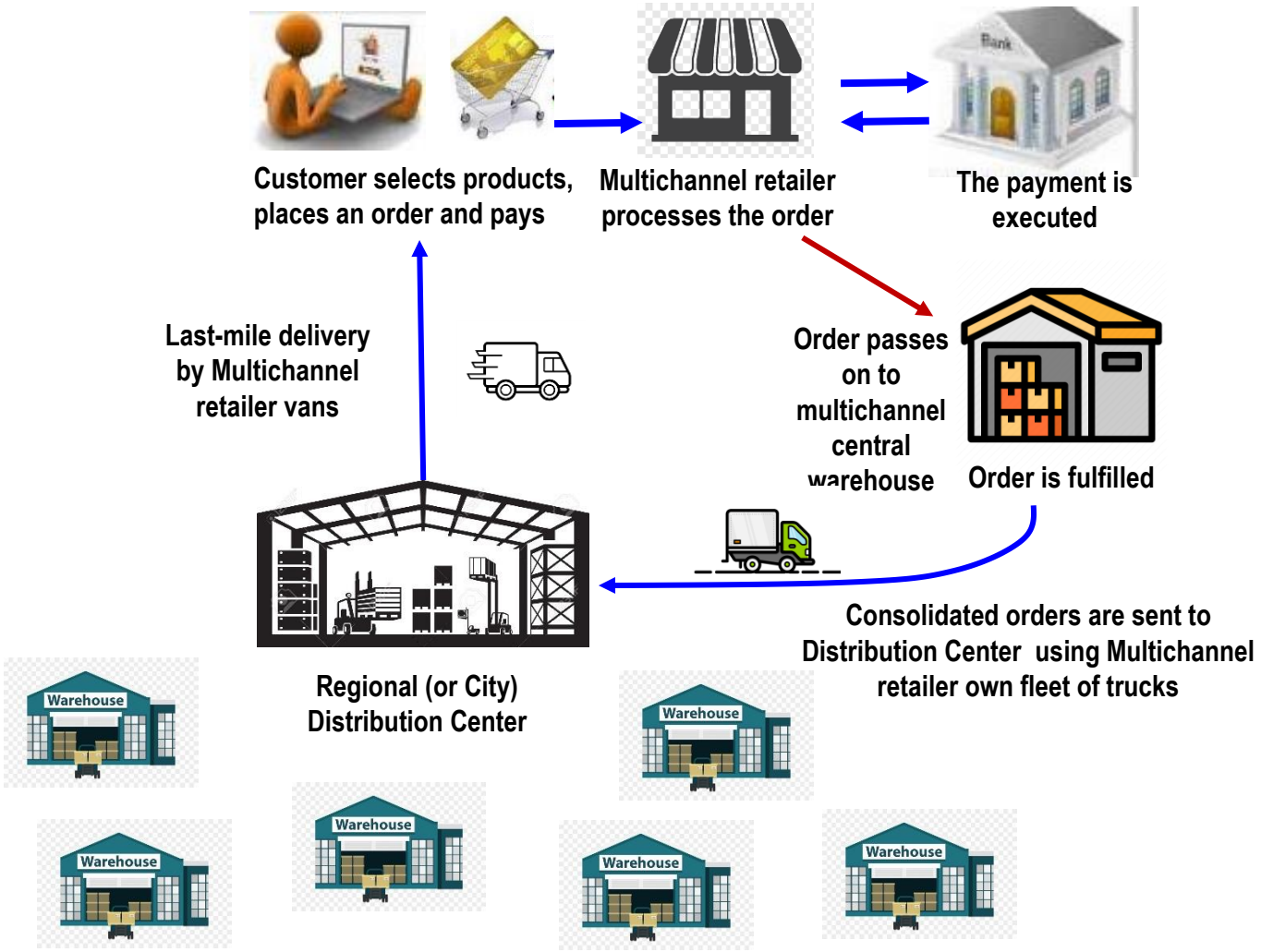
By September 2007, 900 Packstations had been installed across Germany. It is planned that 2,400 will have been installed by 2009

Source: www.packstation.de

PARCEL LOGISTICS PROVIDERS & BROKERS OF COURIER CAPACITY



MULTICHANNEL RETAILERS OPERATING THEIR OWN DELIVERY FLEETS



RECOLLIDA I TRACTAMENT DE LES DADES (DATA ANALYTICS)

LAST-MILE DELIVERY EXAMPLE, DECISIONS AND SOME DATA TO MAKE DECISIONS

DATA:

tt_{ij}^{e} Estimated travel time of route from i to j

tt_{ij}^{r} Recorded travel time of route from i to j

Route from client i to client j are feasible paths in the city road network

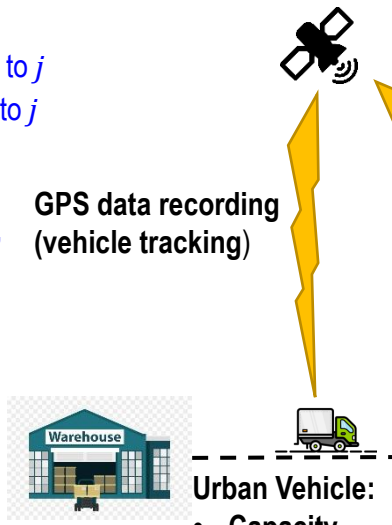
Travel times depend on traffic conditions, congestions may induce auncertainty

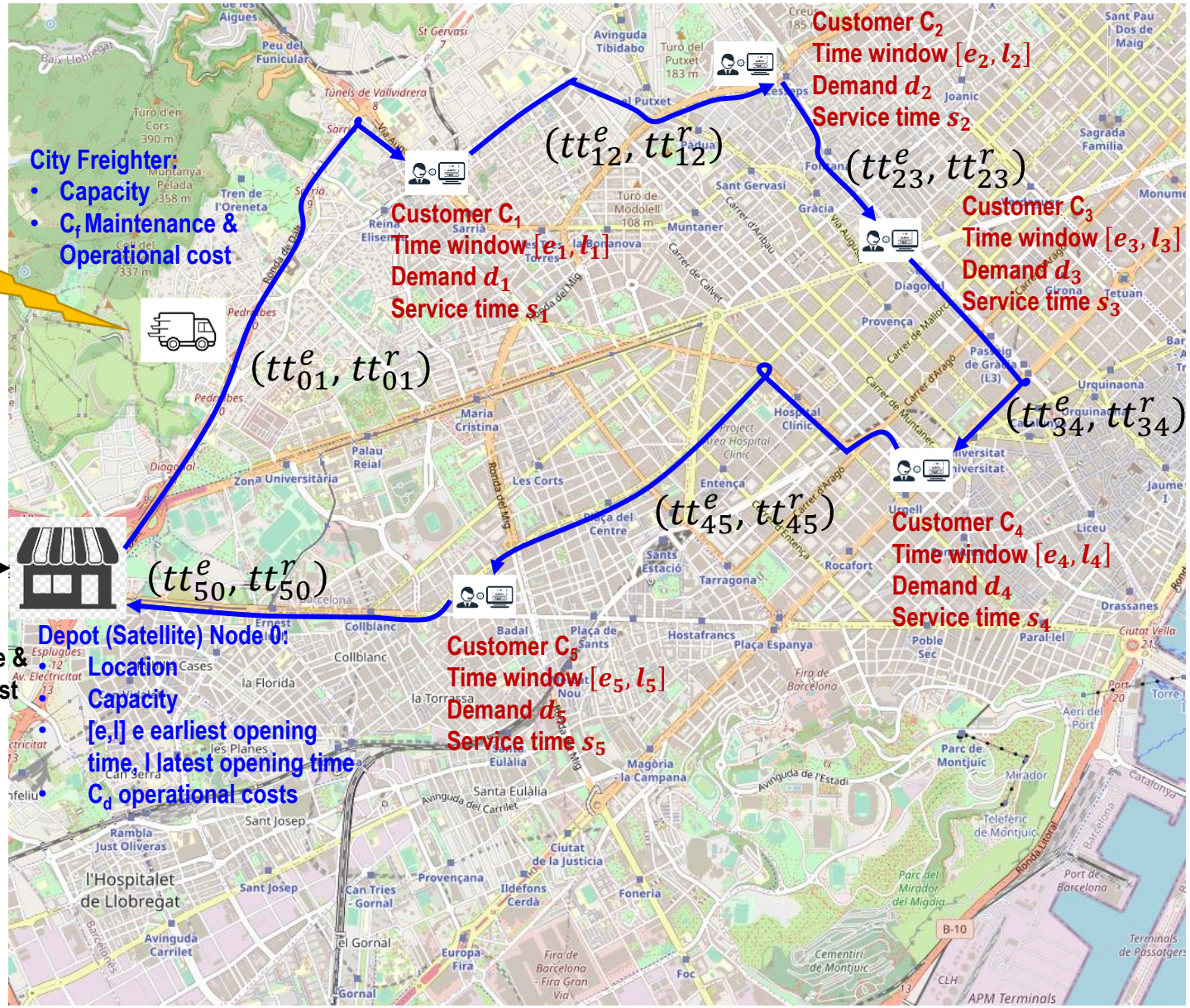
Customer C_i

Time window $[e_i, l_i]$

Demand d_i

Service time s_i

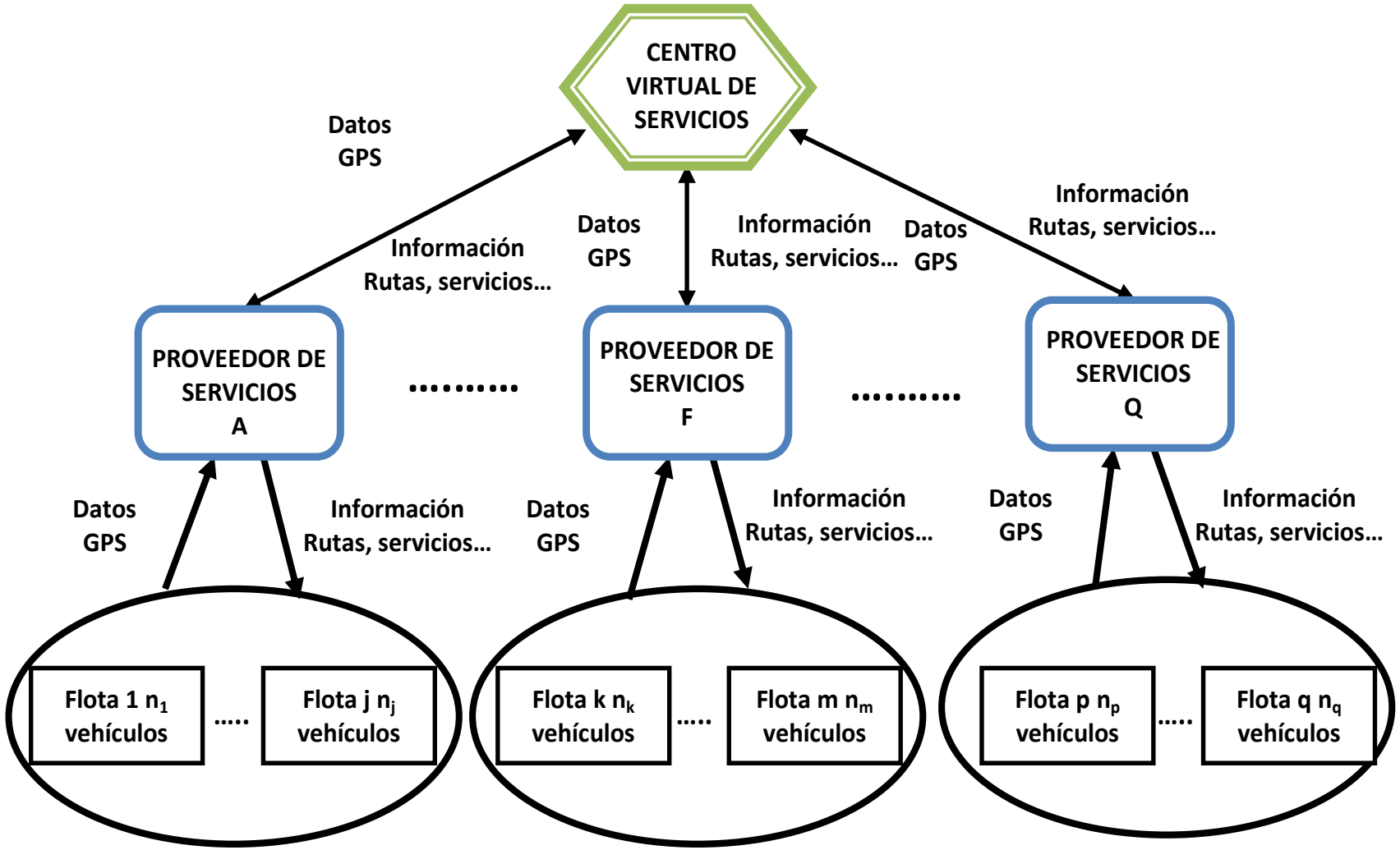




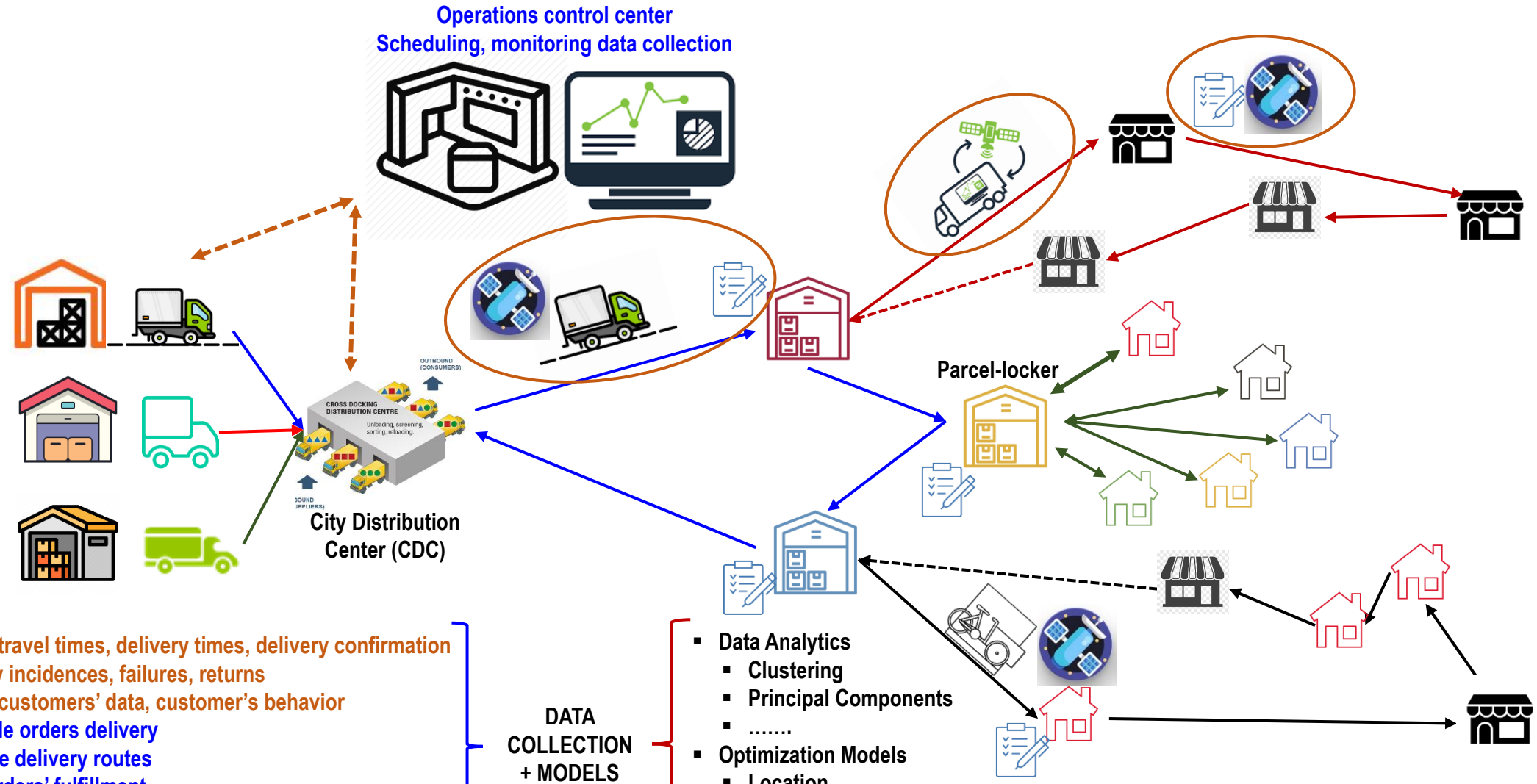
DECISIONS:

- **Where should be located the CDC and the Satellite(s) and Why?**
- **Which are the optimal routing and service scheduling in the current conditions?**

RECOGIDA DE DATOS DE MÚLTIPLES FLOTAS Y SUMINISTRO DE INFORMACIÓN DESDE UN CENTRO VIRTUAL DE SERVICIOS LOGÍSTICOS



DECIDE THE OPERATIONAL SCHEME, COLLECT DATA, MANAGE THE SYSTEM

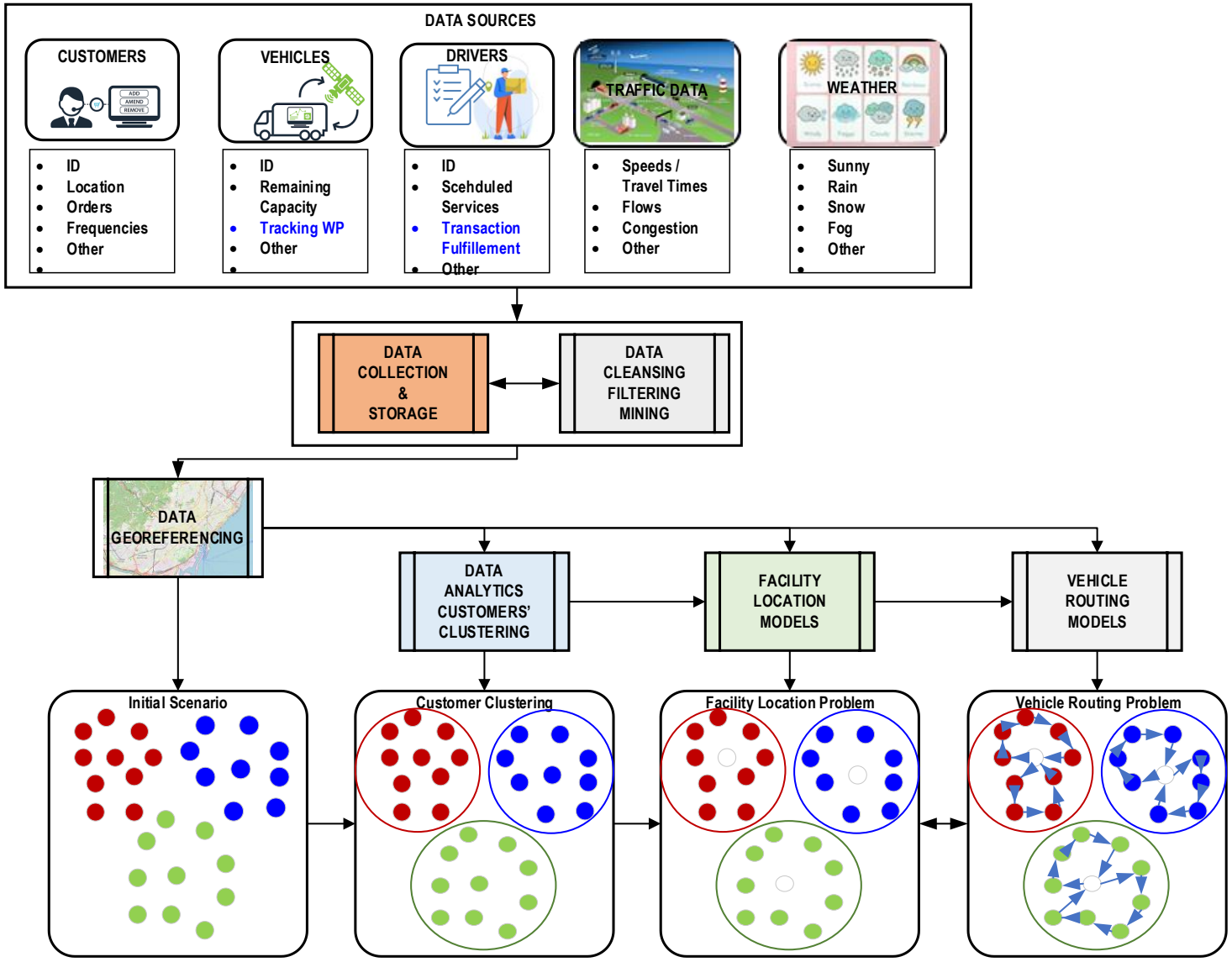


- Collect travel times, delivery times, delivery confirmation
- Delivery incidences, failures, returns
- Collect customers' data, customer's behavior
- Schedule orders delivery
- Optimize delivery routes
- Track orders' fulfillment
- Support data driven decisions in real-time
- Evaluate KPIs to measure efficiency

DATA COLLECTION + MODELS

- Data Analytics
  - Clustering
  - Principal Components
  - .....
- Optimization Models
  - Location
  - Vehicle Routing
  - .....

LAST-MILE DELIVERY CONCEPTUAL DIAGRAM: DATA COLLECTION, PROCESSING, DATA ANALYTICS AND DECISION SUPPORT MODELS



DATA CLEASING, FILTERING AND MINING

- Identify outliers
- Replace missing
- Conduct exploratory data analysis

DATA ANALYTICS/MACHINE LEARNING

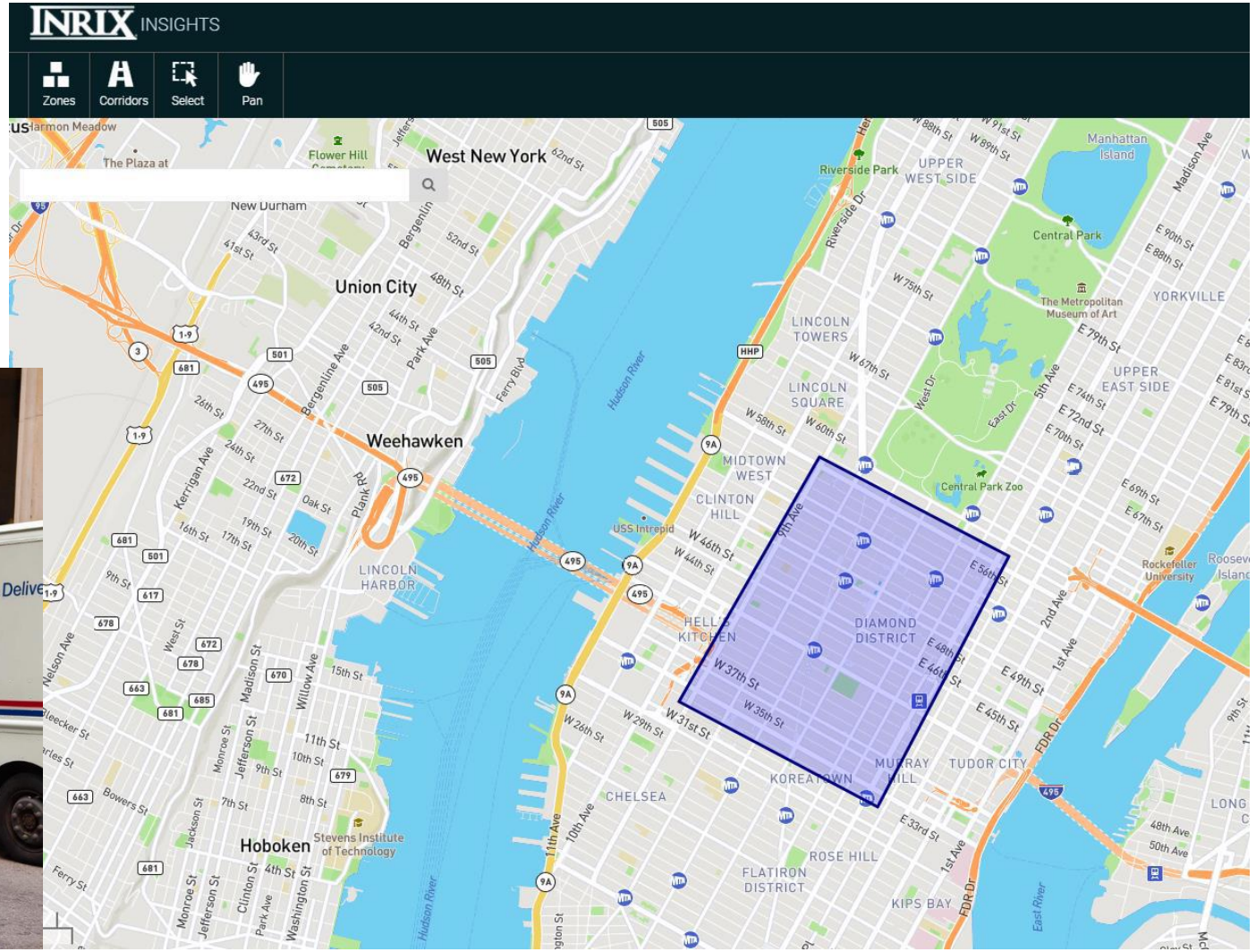
- Descriptive Analysis
  - Principal Components Analysis (PCA)
  - Multivariate Correspondence Analysis (MCA)
  - Profiling (Noticing the difference)
  - Association Rules
  - Clustering
  - Detection Rules
  - ……..
- Predictive Analysis
  - Classification
  - Regression/Multiple Regression/Logistic Regression
  - Neural Networks
  - Decision Trees
  - …..

LOCATION/ROUTING MODELS

- Plant Location
- Vehicle Routing
- Vehicle Routing with Time Windows
- Two-Echelon Location Routing
- ……

IMPACT OF THE DIGITAL ECONOMY: NYC FREIGHT DATA SAMPLE -SELECTION AREA

- Selected all trips that start, end or pass through the box
- Only selected fleet data and only freight profiles (i.e., no taxis)
- Selected all weight classes

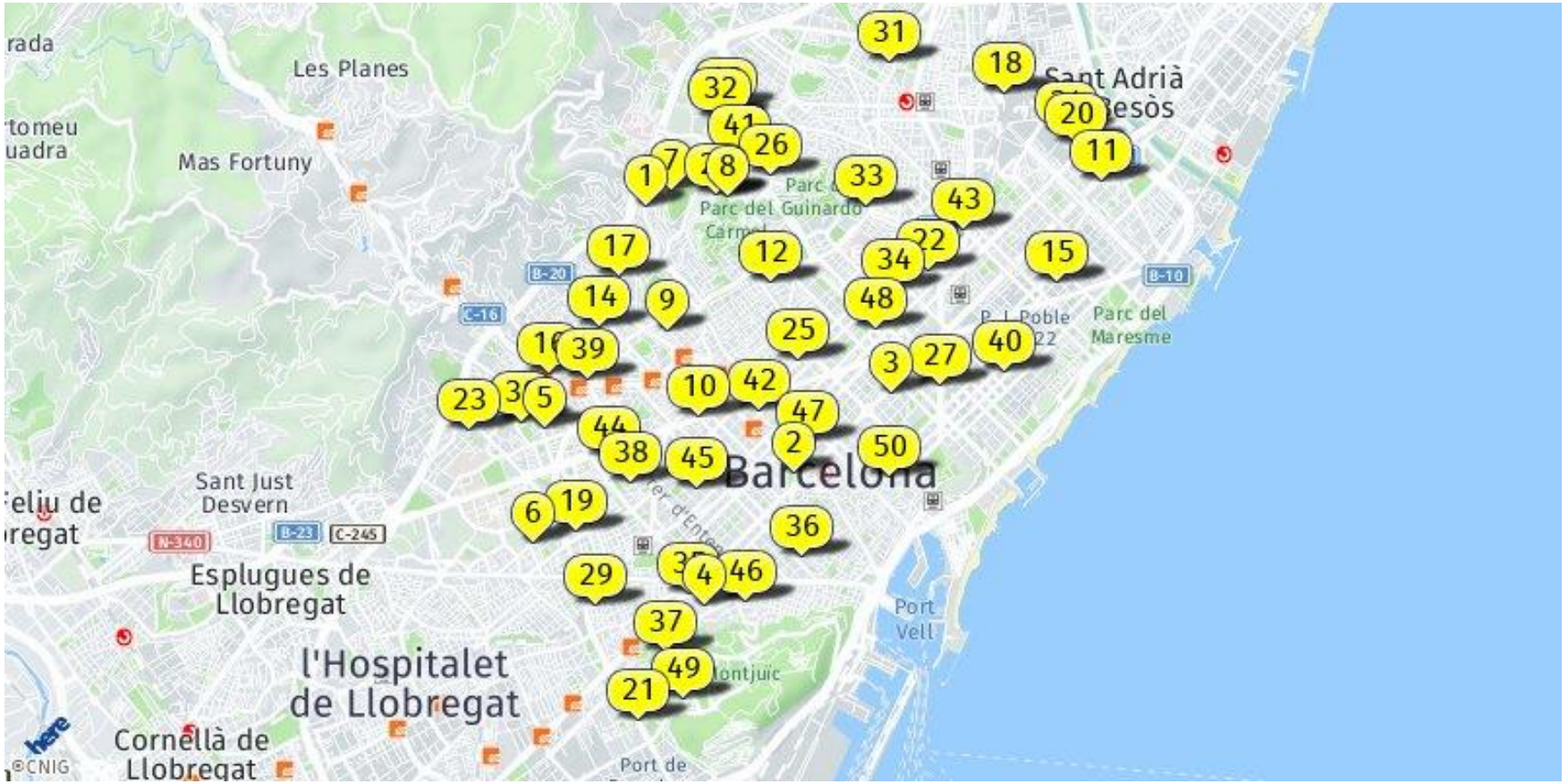


Source: Inrix Carlin, SF-Bay ITE 2018, Big Data Presentation

CUSTOMERS DATA COLLECTION

Clients Database

- Customer ID
- Longitude of City Distribution Centre to which the customer is assigned
- Latitude of City Distribution Centre to which the customer is assigned
- Customer Longitude
- Customer Latitude
- Type of Customer's Demand
- Amount(s) ordered
- Frequencies
- Average service time
- ….



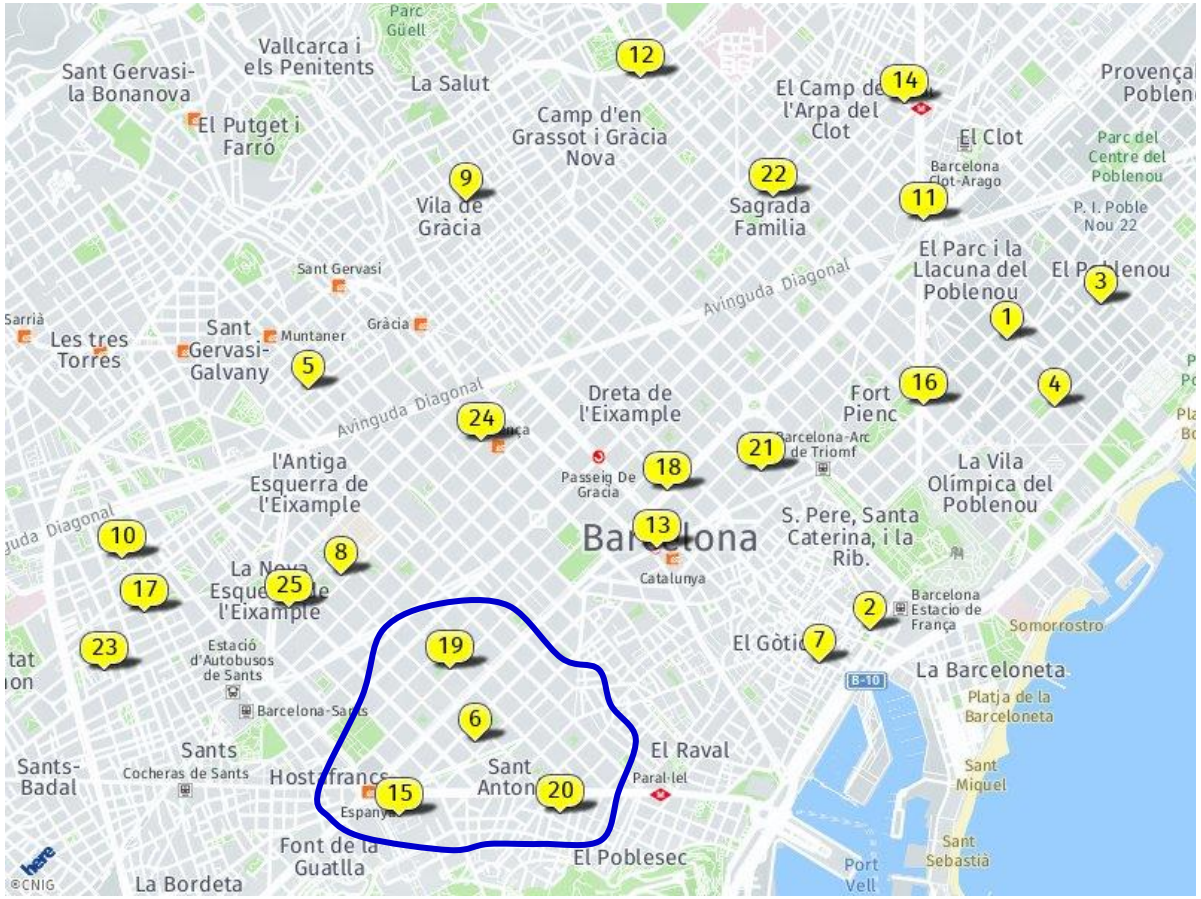
Locations of 50 customers of Company XYZ

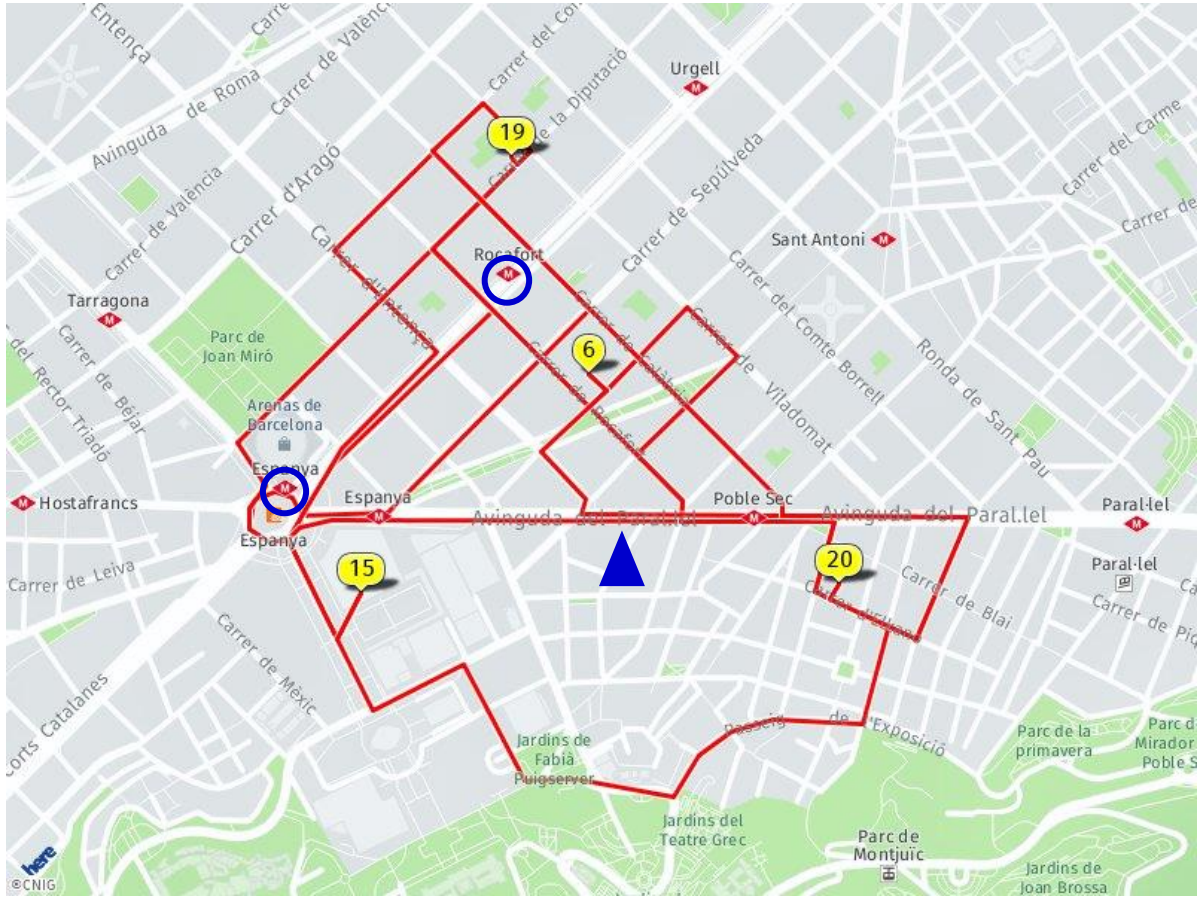
OUTPUT: CUSTOMERS' LOCATIONS, DISTANCES, TRAVEL TIMES

client-i		client-j		distance (m)	traveltime (s)
Latitude	Longitude	Latitude	Longitude		
41,3688695246203	2,1375346382749	41,4199612074855	2,2095954278571	8939	1447
41,3688695246203	2,1375346382749	41,3871135646669	2,1149689196456	4655	717
41,3688695246203	2,1375346382749	41,4069294925461	2,1516999525298	6118	782
41,4199612074855	2,2095954278571	41,3688695246203	2,1375346382749	12954	1463
41,4199612074855	2,2095954278571	41,3871135646669	2,1149689196456	17295	1365
41,4199612074855	2,2095954278571	41,4069294925461	2,1516999525298	7734	1420
41,3871135646669	2,1149689196456	41,3688695246203	2,1375346382749	3950	604
41,3871135646669	2,1149689196456	41,4199612074855	2,2095954278571	16298	1361
41,3871135646669	2,1149689196456	41,4069294925461	2,1516999525298	5159	801
41,4069294925461	2,1516999525298	41,3688695246203	2,1375346382749	6801	903
41,4069294925461	2,1516999525298	41,4199612074855	2,2095954278571	6707	1145
41,4069294925461	2,1516999525298	41,3871135646669	2,1149689196456	6955	864

Locations of 50 customers of Company XYZ

CUSTOMERS' CLASSIFICATION (CLUSTER ANALYSIS) & IDENTIFICATION OF CANDIDATE LOCATIONS FOR SATELLITES





FLEXIBLE LAST-MILE DELIVERY APPROACHES

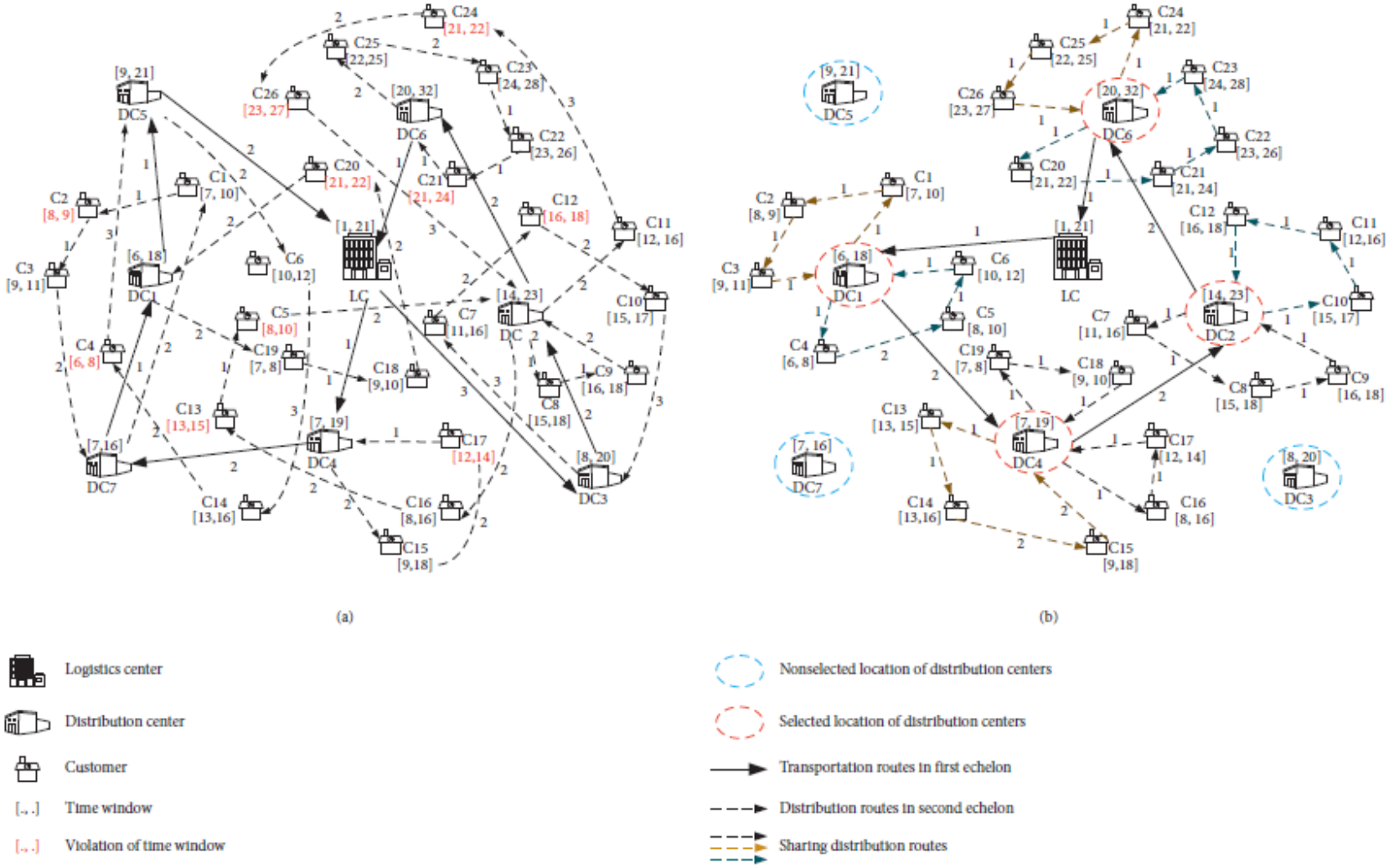
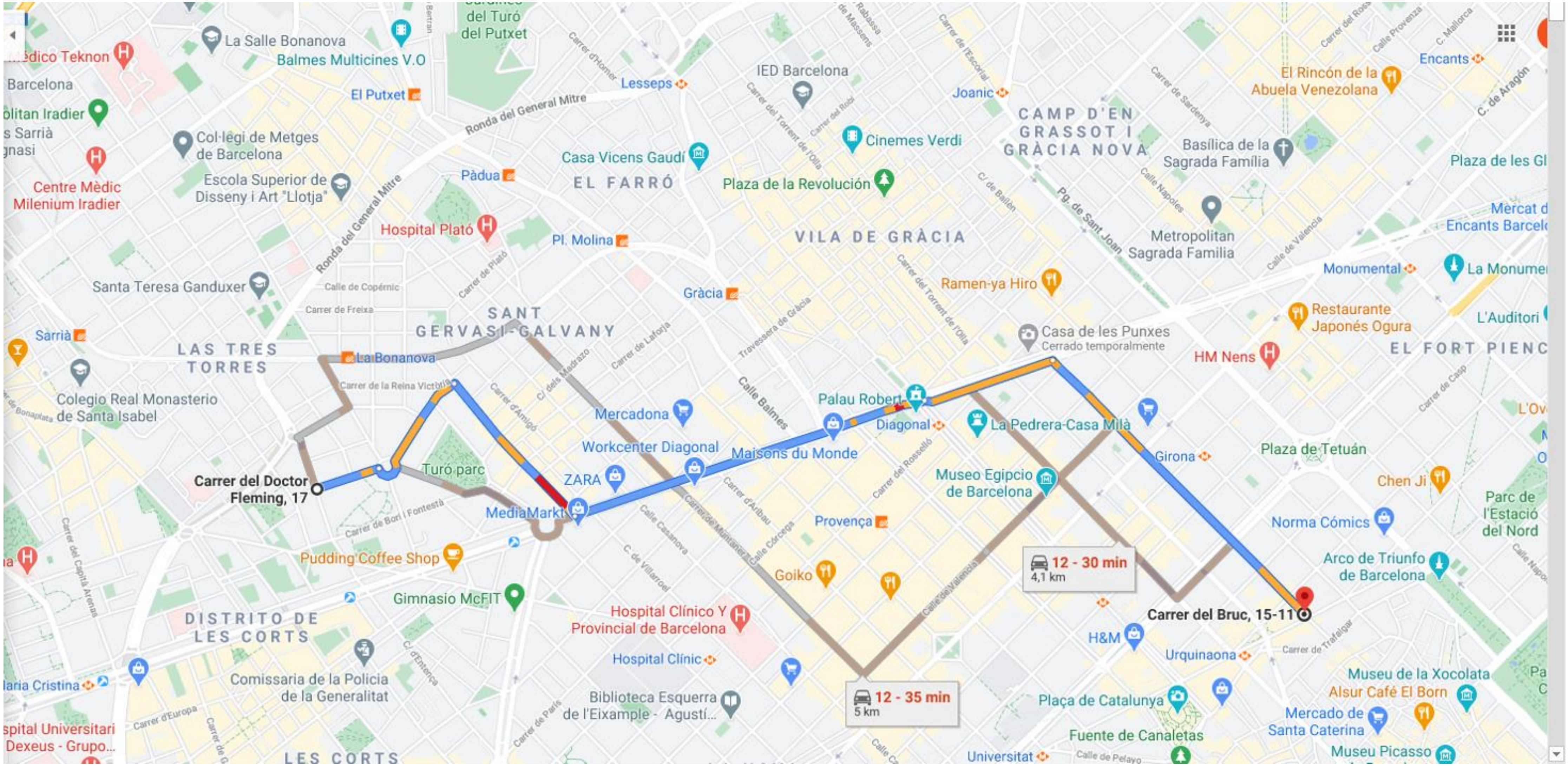


FIGURE 1: Illustration of 2E-LRPTWTRS optimization. (a) Initial logistics network and (b) optimized logistics network.

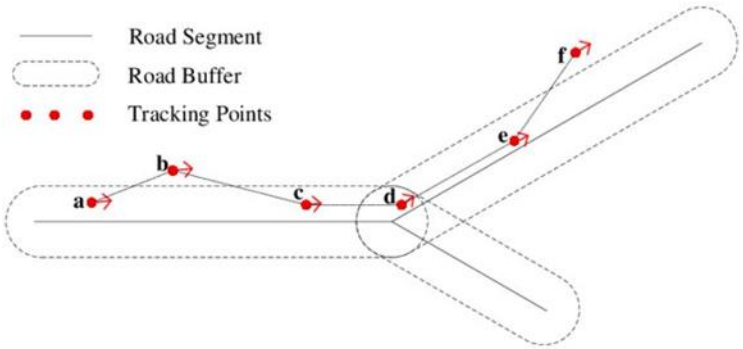
Source: Yong Wang, Kevin Assogba, Yong Liu, Xiaolei Ma, Maozeng Xu, Yinhai Wang, Two-echelon location-routing optimization with time windows based on customer clustering, Expert Systems with Applications, Volume 104, 15 August 2018, Pages 244-260

PATHS &TRAVEL TIME INTERVALS AS PROVIDED BY GOOGLE TRAFFIC



FROM WAYPOINTS TO LINK TRAVEL TIMES

ID	Date	Time Tag	Latitude	Longitude	Type
4261353	2015-11-30	22:43:58	45.445988	9.124048	car
4261353	2015-11-30	22:44:57	45.445496	9.121952	car
4261353	2015-11-30	22:45:57	45.444817	9.119162	car
4261353	2015-11-30	22:46:57	45.444828	9.119143	car
4261353	2015-11-30	22:47:57	45.444832	9.119166	car
4261353	2015-11-30	22:48:57	45.444782	9.119164	car
4261353	2015-11-30	22:49:57	45.444794	9.119179	car
4261353	2015-11-30	22:50:57	45.444767	9.119217	car
4261355	2015-11-30	22:43:58	45.44598	9.124048	truck
4261355	2015-11-30	22:44:57	45.445496	9.121952	truck
4261355	2015-11-30	22:45:57	45.444817	9.119162	truck
4261355	2015-11-30	22:46:57	45.444828	9.119143	truck
4261355	2015-11-30	22:47:57	45.444832	9.119166	truck
4261355	2015-11-30	22:48:57	45.444782	9.119164	truck
4261355	2015-11-30	22:49:57	45.444794	9.119179	Truck
4261355	2015-11-30	22:50:57	45.444767	9.119217	truck
.....	.....	.....	.....	.....	.....



TRANSPORTATION SYSTEM

GPS DATA

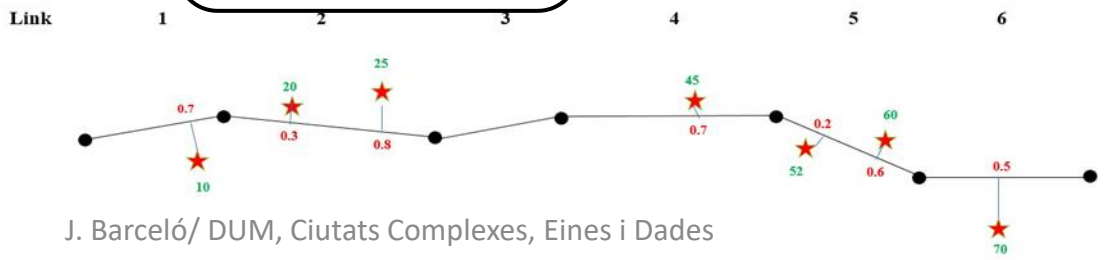
MAP MATCHING

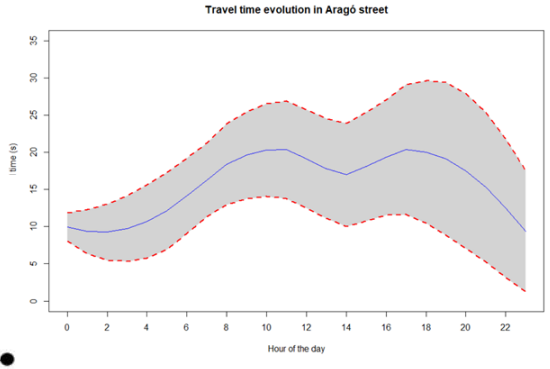
LINK TRAVEL TIME ESTIMATION

GPSS DATA ERROR ASSESSMENT

INPUT TO TRANSPORT MODELS (CVRPTW,PDPTW...)

DESCRIPTIVE ANALYSIS & VISUALIZATIONS





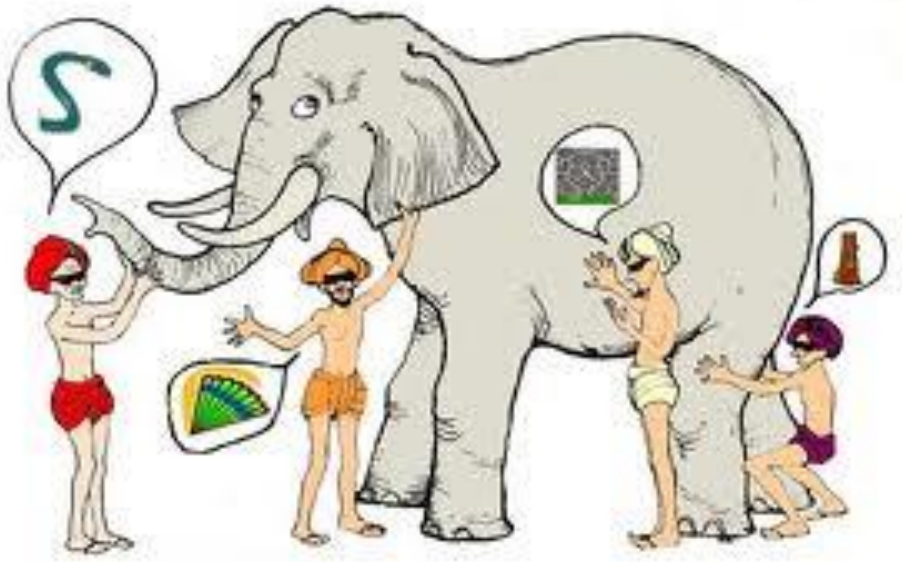
A PLANNING PERSPECTIVE: UNDERSTANDING URBAN FREIGHT TRANSPORT IN A METROPOLITAN AREA

CONSIDERACIONS INICIALS

- Pel que fa a la modelització del transport urbà de mercaderies, amb excepció dels models LUTI (Land Use Transportation Interactions), la major part dels models de transport urbà de mercaderies tenen poques connexions amb les característiques de les ciutats i els criteris espacials malgrat llur influència amb els aspectes tècnics i econòmics de la DUM $\Rightarrow$ models DUM $\Leftrightarrow$ models espacials de la ciutat.
- Necessitat d'incloure els models DUM amb els models de planificació urbana
- Considerar l'anàlisi de l'accessibilitat espacial i capacitats d'atracció
- Combinar la recollida de dades i l'emmagatzemament amb les eines analítiques que permeten treure conclusions de situacions complexes i presentar-les de manera entenedora als responsable de la presa de decisions.

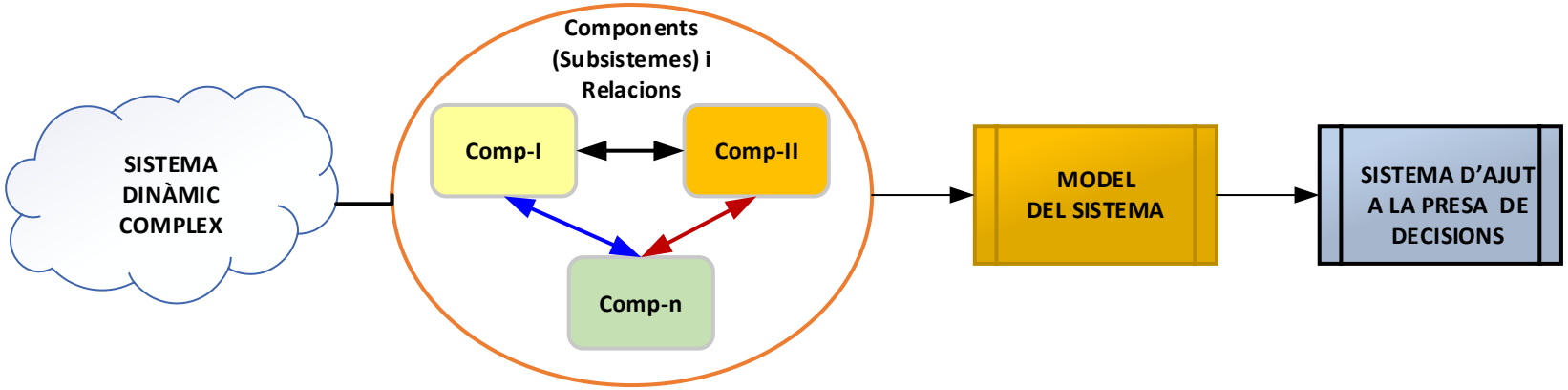
HEM DE CANVIAR ELS PLANTEJAMENTS

D'UN ENFOCAMENT CONVENCIONAL REDUCCIONISTA
(La paràbola dels cecs visitant un elefant)

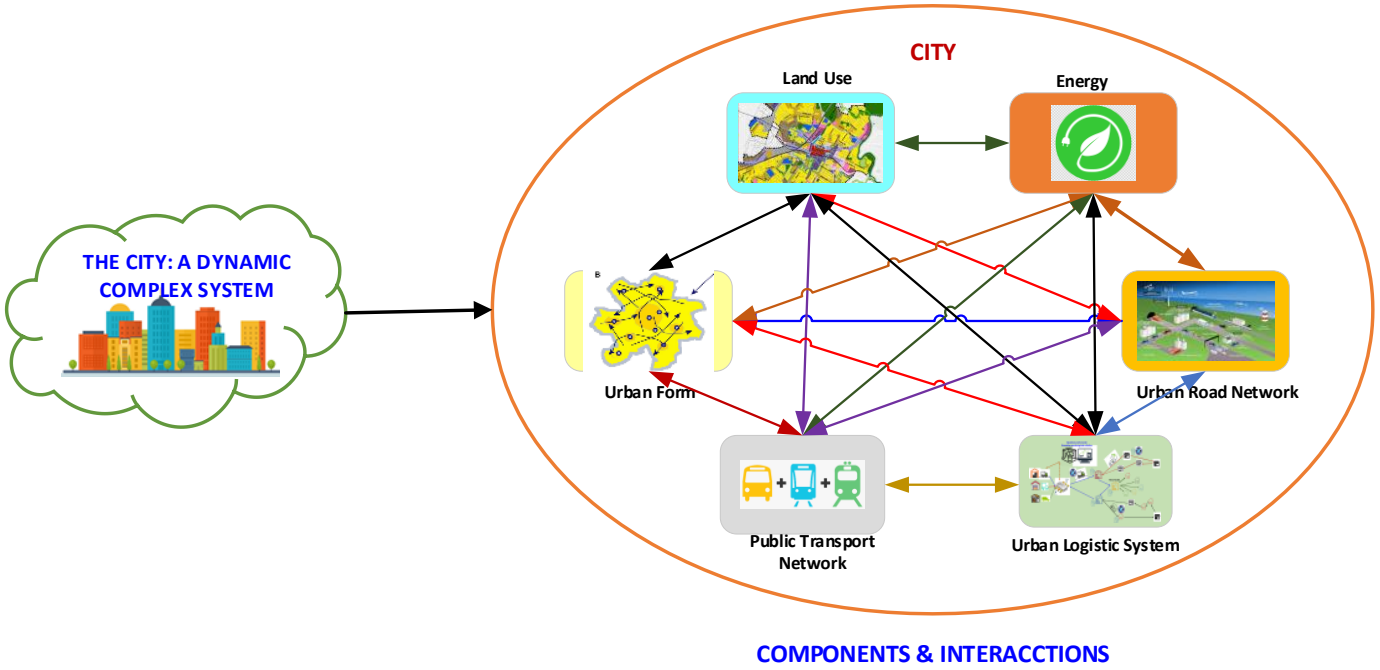


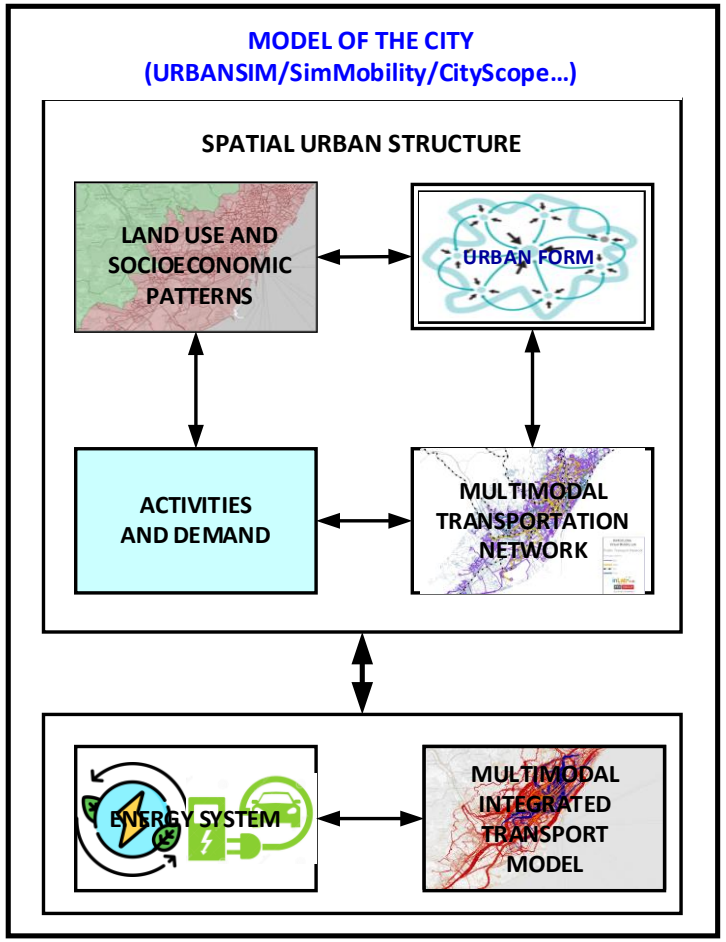
A UN ENFOCAMENT DE DINÀMICA DE SISTEMES

Un **sistema complex** és un sistema compost per un **gran nombre de components que interactuen entre si**, de manera que, en conjunt, como un tot, exhibeixen propietats que no són obvies a partir de les propietats de les components individuals (**Perspectiva holística: el tot és diferent de la suma de les parts**). Especialment en el cas dels sistemes complexos dinàmics als que **les interaccions entre components poden ser contraïntuitives (j. forrester/urban dynamics)**



MODELANT LA CIUTAT (ÀREA METROPOLITANA) COM A SISTEMA COMPLEX



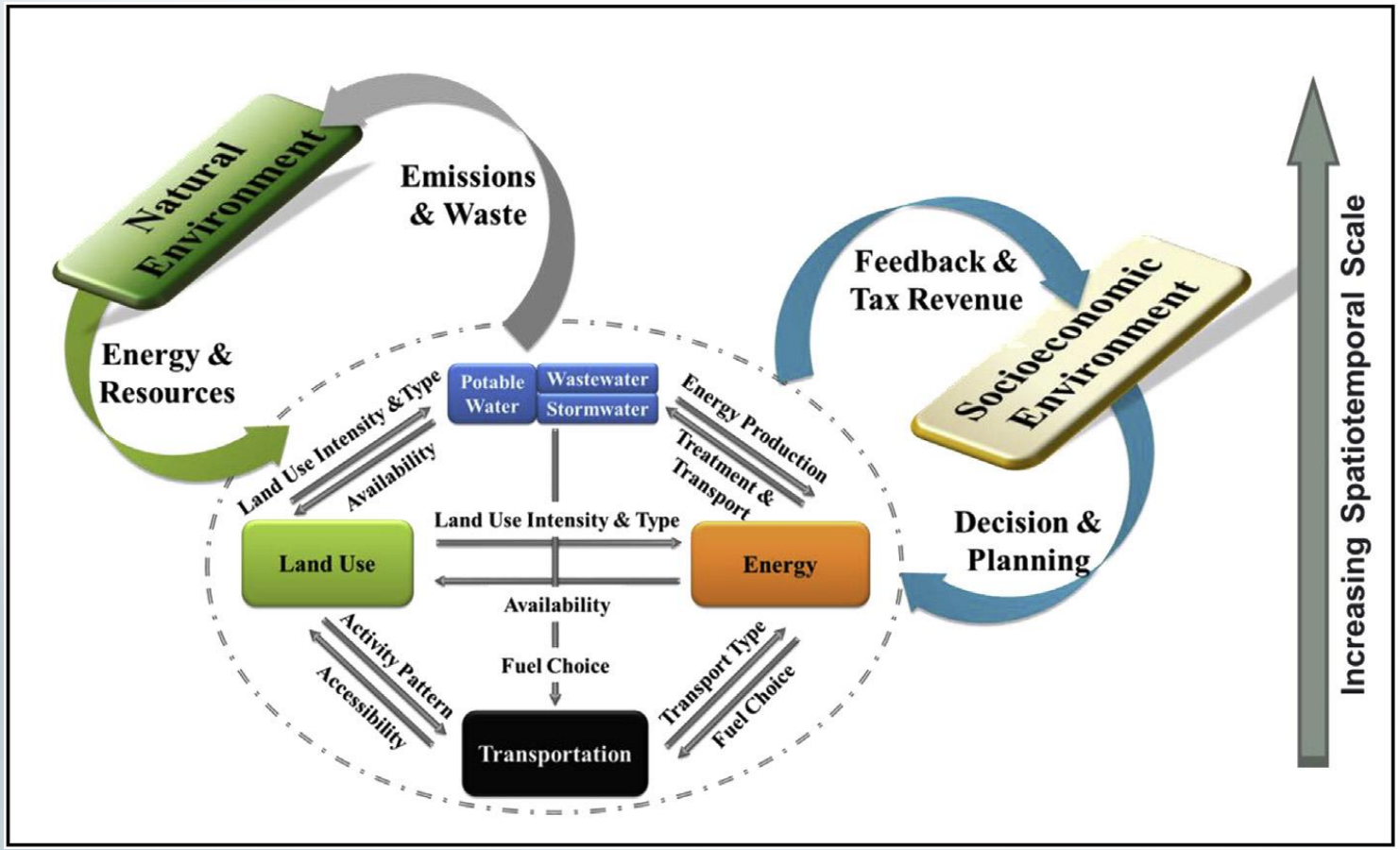


DEL(S) MODEL(S) DEL(S) SISTEMA(ES) DE TRANSPORT PRIVAT/PÚBLIC/LOGÍSTICA URBANA
AL MODEL DE LA CIUTAT: FORMA URBANA /ÚS DEL SÓL/XARXA INTEGRADA DE TRANSPORT
MODEL D'ENERGIA & XARXES D'ELECTROLINERES (PUNTS DE CÀRREGA), Etc.

URBANSIM
SimMobility
CityScope

J. Barceló (2019), Future trends in sustainable transportation, in "Sustainable Transportation and Smart Logistics. Decision Making Models and Solutions", Editors: J. Faulin, S. Grasman, A. Juan, P. Hirsch, Elsevier

EN UN CONTEXT DE SOSTENIBILITAT (METABOLISME URBÀ)



- **The notion of *modelling urban areas using the analogy of biological metabolism* is conceived as a cycle in which materials enter the city to sustain the population, build up infrastructure, and exit as waste and residues**
- **"The metabolic requirements of a city can be defined as all the materials and commodities needed to sustain the city's inhabitants at home, work and play...The metabolic cycle is not completed until the wastes and residues of daily life have been removed and disposed with a minimum nuisance and hazard.**

Source: Pandit, A., et al., 2015. Infrastructure ecology: an evolving paradigm for sustainable urban development, Journal of Cleaner Production, http://dx.doi.org/10.1016/j.jclepro.2015.09.010

URBAN FREIGHT DATA COLLECTION: FACTS AND METHODOLOGICAL REFERENCES

- There is no commonly available source of data on freight movements within metropolitan areas.
- Different levels of government collect data at various geographical scales and within political boundaries that are not always compatible.
- A large proportion of freight data belongs to the private sector and there is no protocol for researchers to share it. Moreover, there has been no systematic work that successfully integrates freight data from different sources

SOME METHODOLOGICAL REFERENCES

- MetroFreight Center of Excellence, Sol Price School of Public Policy, University of Southern California Los Angeles, California, USA. Building the Database,Project Number: 15-1A. Genevieve Giuliano, Laetitia Dablanc, Jean-Paul Rodrigue, Sangbeom Seo, Sanggyun Kang
- Survey Techniques in Urban Freight Transport Studies.Transport Reviews, Vol. 32, No. 3, 287–311, May 2012. Julian Allen, Michael Browne and Tom Cherrett
- L'enquête transport de marchandises en ville. Guide méthodologique (2016). Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement (CEREMA) www.cerema.fr

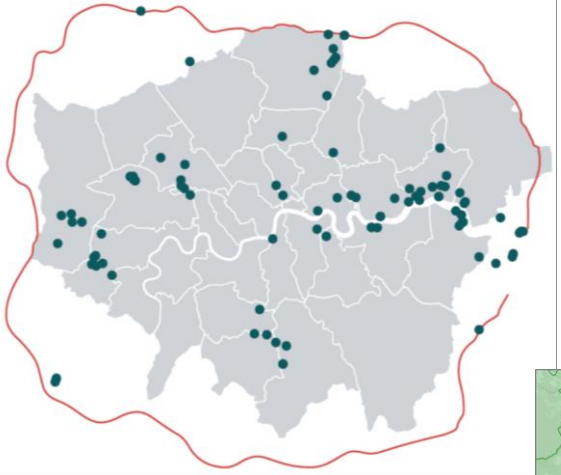
- Most frequently urban freight transport is analyzed from vehicle's activities perspective:
  - Vehicles cause traffic and environmental impacts
  - Their performance servicing the demand, which determines companies' profitability
- However, it is important to bear in mind that **the demand for urban freight transport activity is derived from the demand for goods and service flows**
  - goods and services consumed in the urban system → demand
  - vehicle activity supports the flow of these goods and services from origins (i.e. CDC, Satellites…) to destinations (delivery points)
- **Remark**: a global, systemic view of urban freight transport must account for the set of journeys to serve the demand of goods in the urban area, as well as, waste collection resulting from the urban metabolism, both being necessaries for the realization of the economic activities.
- **Note**: this seminar will only address the case of servicing the demand for goods in the urban area
- Therefore, it is recommendable to set up a methodology to collect the necessary data to properly manage the system:
  - Identify the **geographic area** and **business types** to be considered
  - The **types of data** to be collected
  - The **data collection methods**:
    - **Surveys**
    - **Automatic Data Collection**

EXAMPLES OF DATA TYPES (I)

- Identification of the Geographic Area, i.e. a Metropolitan Area
- Definition of the Granularity/spatial units
  - Census tracts
  - Transportation analysis zones (TAZ)
  - Municipalities
  - Districts
- Infrastructure
  - Freeway/highway/arterial system
  - Public transportation: Transit lines, stops, and attributes
- Warehousing and distribution centers, container depots
- Facility locational, operational, **land-use**/zoning and physical characteristics

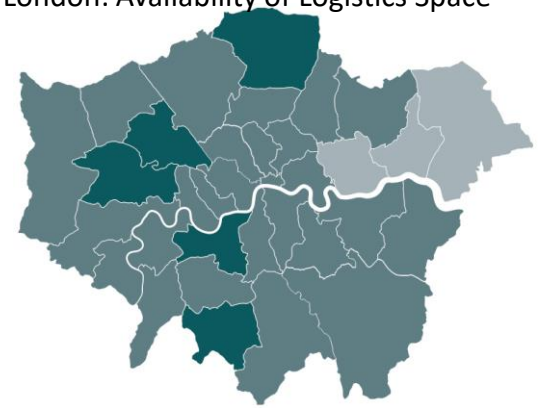
Data format: All spatial data is usually geo-coded in Shapefile GIS format

London: Geographic Area



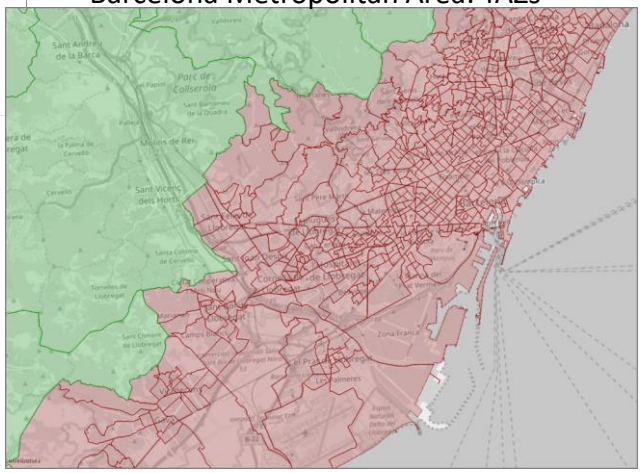
London: CDCs

London: Availability of Logistics Space

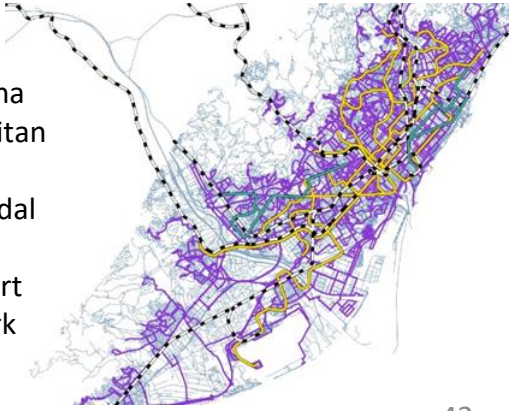


Barcelona Metropolitan Area: Road Network

Barcelona Metropolitan Area: TAZs



Barcelona Metropolitan Area: Multimodal Public Transport Network



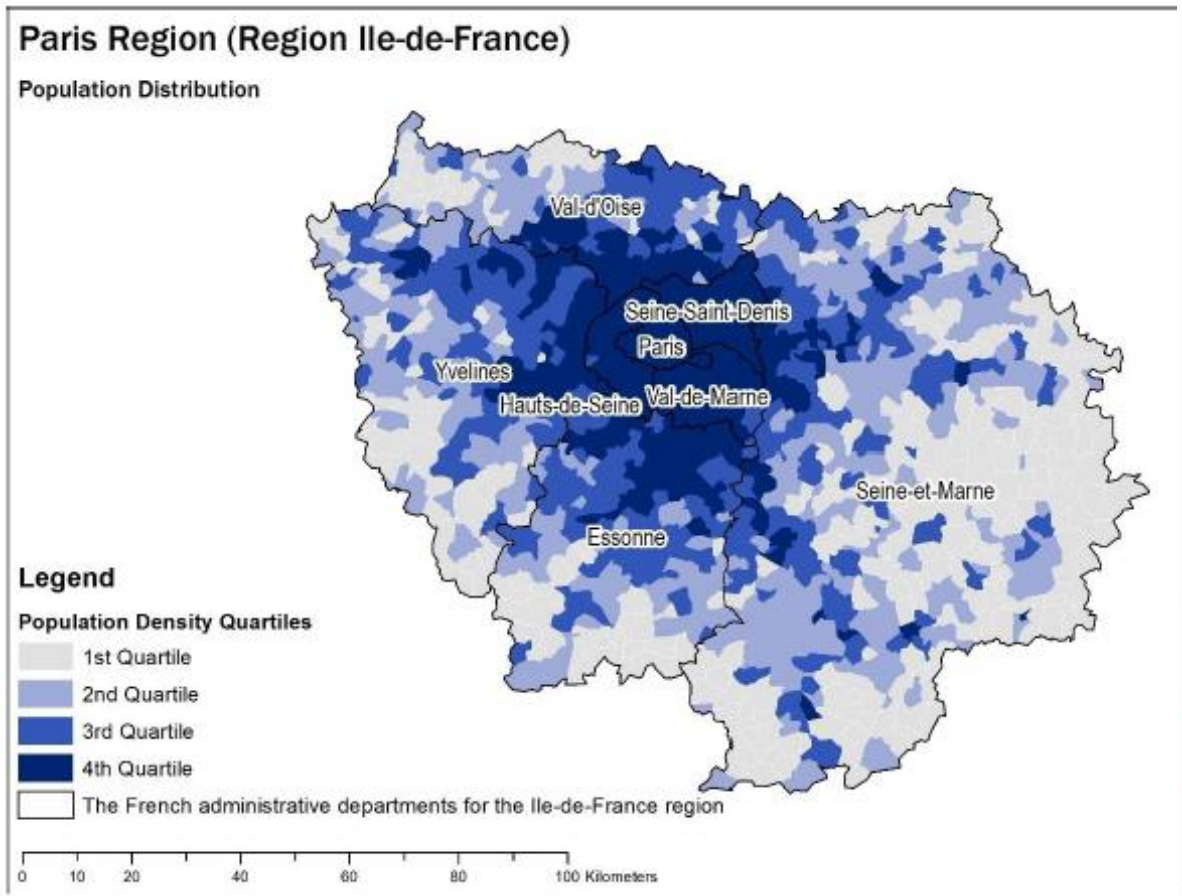
EXAMPLES OF DATA TYPES (II)

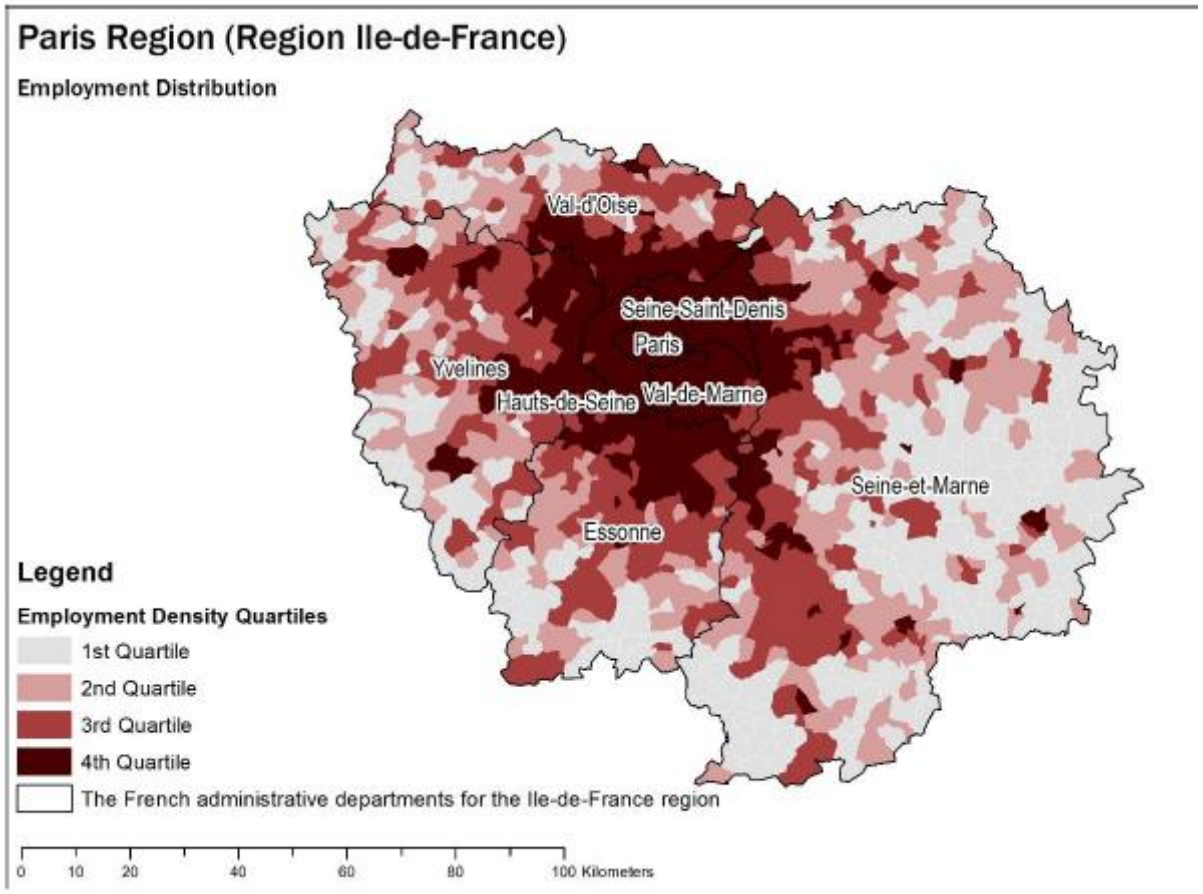
- *Land use*
  - Population characteristics
  - Population counts and socio-economic characteristics by spatial unit
  - Employment characteristics
  - Jobs, establishments by spatial unit and by industry sectors, annual/decennial
  - Densities
    - Population and employment density calculated based on the population and employment counts per area
- *Flows*
  - Vehicle fleet data
  - Number of registered vehicles by type, size, age, fuel type (diesel, CNG, electric; non-motorized)
  - Transport flows
    - Local truck flows: volume, frequency, deliveries/pickups, loading/unloading activities
    - Metropolitan freight flows from traffic monitoring systems and regional travel models
    - Freight flows
      - by mode (land, water, or air),
      - by time of day (AM/PM peak; workday/weekend),
      - by type of vehicle (truck size, weight, axle number, train tonnage, number of cars, etc.)
    - Freight flows on link-based loaded networks and origin-destination matrices
    - Commodity and freight flow estimation to/from/within region by ton/value, by industry sector, by commodity type, mode of travel, and by trade hubs
- *Policies and regulations*
  - Traffic regulations
  - Truck parking regulation on streets
  - Long term and short-term loading zones
  - Truck route/zone restrictions by weight and vehicle type
  - Oversized truck regulation
- Fuel and emissions regulations
  - Truck and locomotive fuel economy and emission standards by governance level (national, regional, and local standards) by fuel type, engine size or vehicle weight
- Operator regulations
  - Freight facility operation: intermodal, and warehousing facility operation, hours of service, type of commodity
  - Vehicle operation: pickup and delivery, loading/unloading regulations

B2B

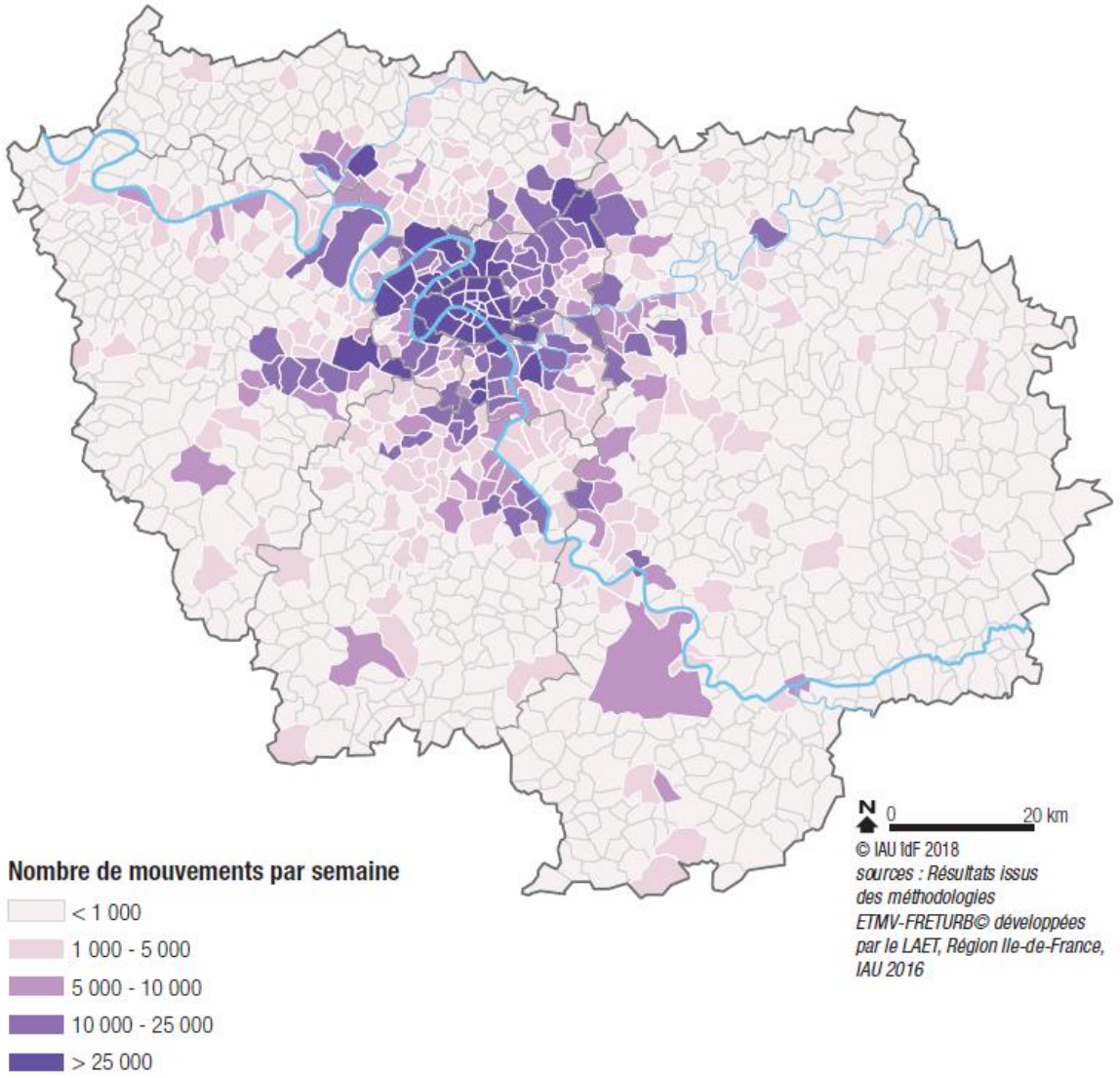
Freight Distribution to the 96,000 retail shops and establishments in the City (60% before 11:00am)

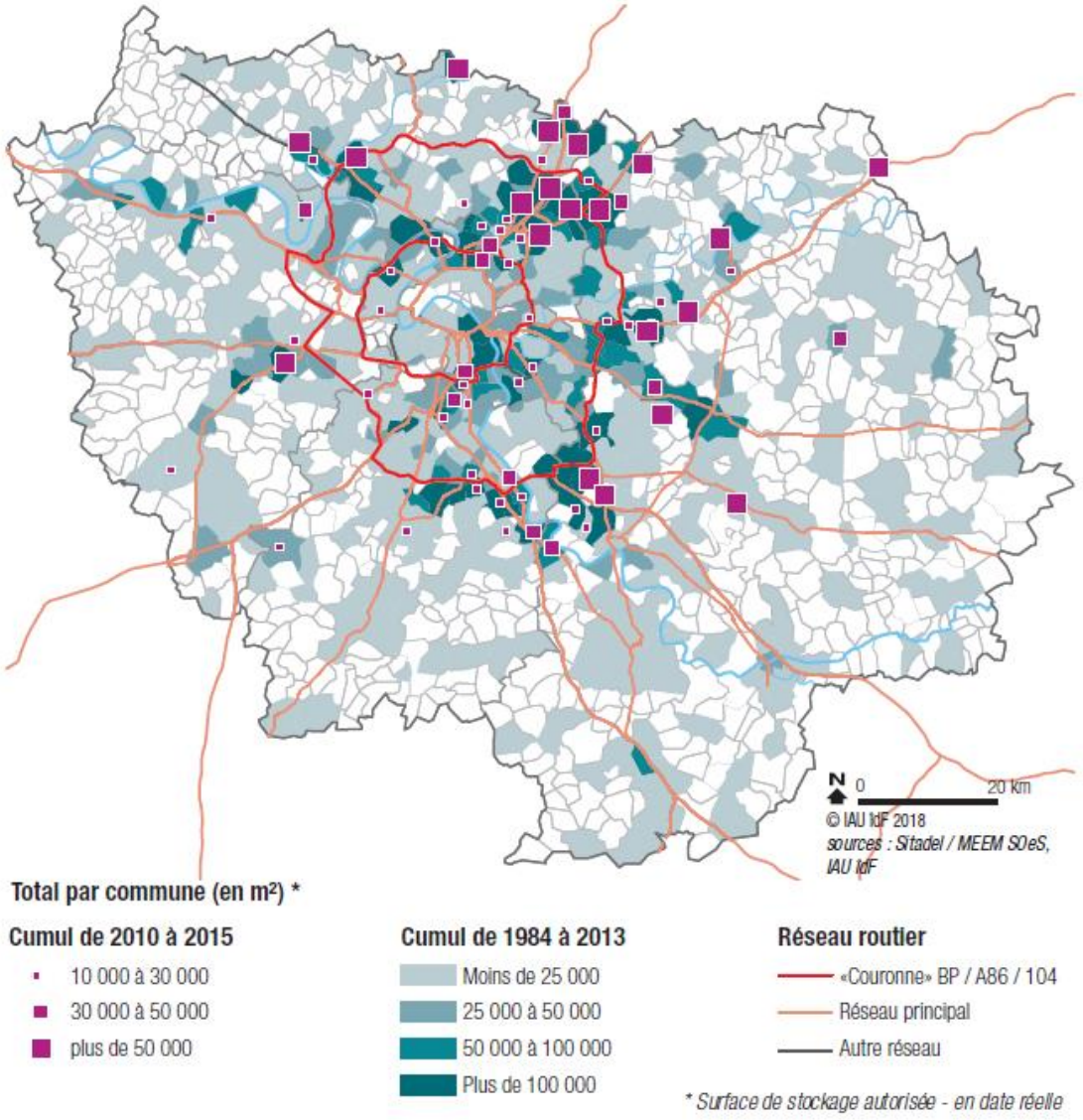
FRETURB (From FRETURB to SILOGUES): Primary Data Analysis and visualizations for the Region Île-de-France





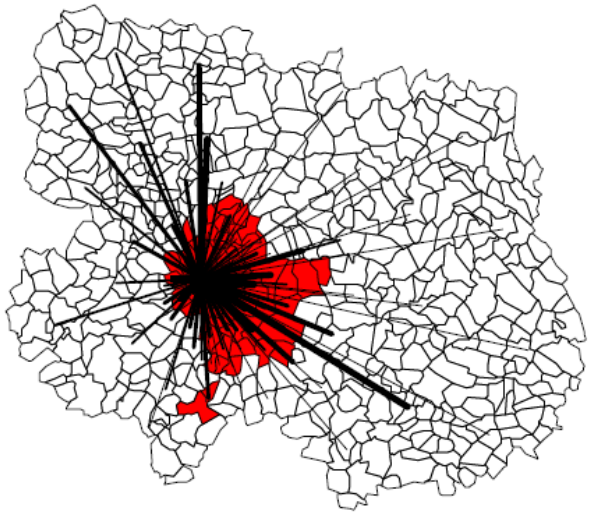
Les mouvements (livraisons, enlèvements) générés par les emplois en Île-de-France
Le parc logistique immobilier : stock et dynamique les cinq dernières années

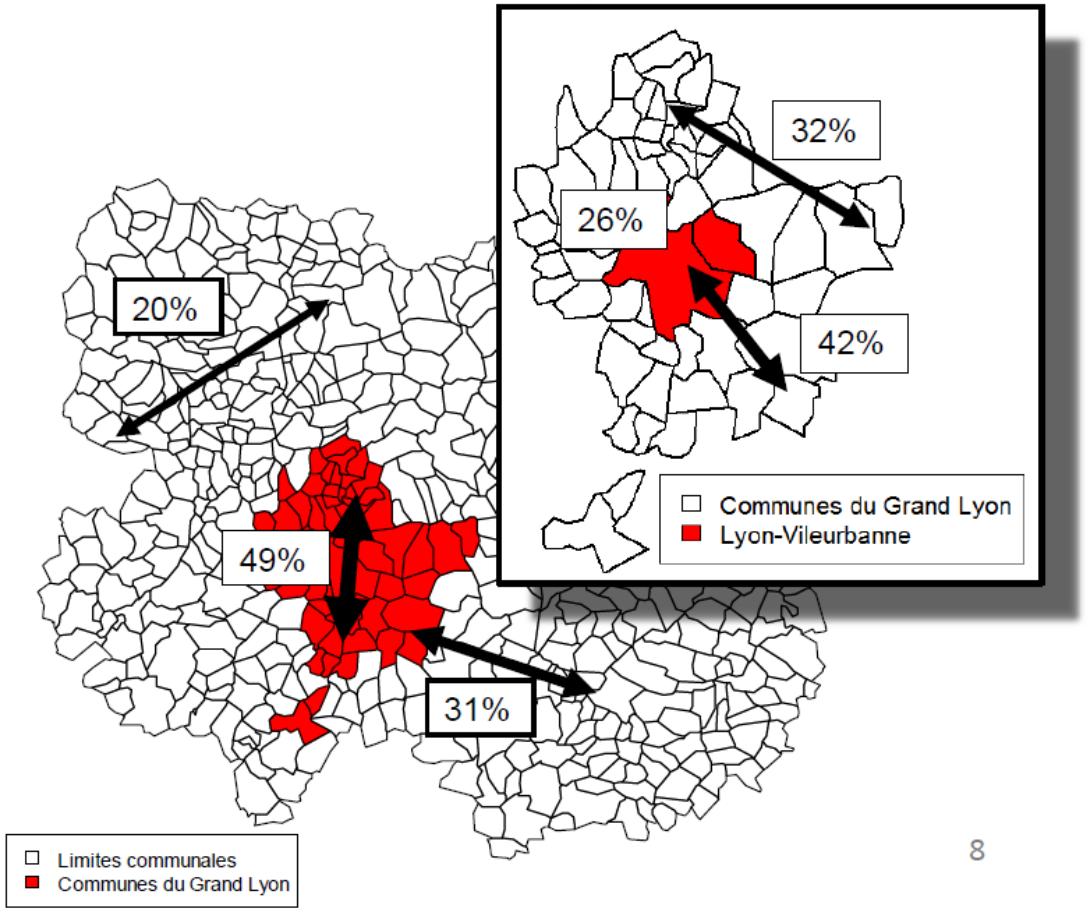




Freturb, un diagnostic des mouvements de marchandises fondé sur les enseignements des ETMV (3/3)

- Distribution des flux zone à zone ;
- Possibilité d'estimation par mode de gestion, type de véhicule, activités… ;





8

Font. F. Toilier, "De Freturb à Silogues, intérêts et limites. Laboratoire Aménagement Économie Transports.

SOME EXAMPLES OF DATA COLLECTION METHODS (I)

Establishment survey: collects data

- about total goods vehicle trips to/from surveyed establishments, and variation by time, day and month.
- about type of goods delivered/collected.
- information about the delivery/collection process: vehicle types, time taken to load/unload, where vehicles stop (establishment premises, loading/unloading spots,…), method of goods movement from the vehicle (manual, assisted…), and **origin** of vehicle/goods trips

Survey methods: personal or telephone interviews, GPS data, electronic transactions

Freight operator, Supplier & Service Provider surveys

- Collects wide ranging data about the pattern of freight operators' goods vehicle activities in the urban area.
- Data can be obtained on the entire vehicle fleet rather than just a single vehicle or round
- It also provides qualitative information about problems encountered by the company in urban freight operations.
- Gathers information from suppliers about the goods they dispatch to urban establishments and the vehicle activity that supports this goods flow.
- Provides more detailed information about vehicle activity if suppliers operate their own goods vehicles to make deliveries (in which case the data captured are similar to that from freight operator surveys)

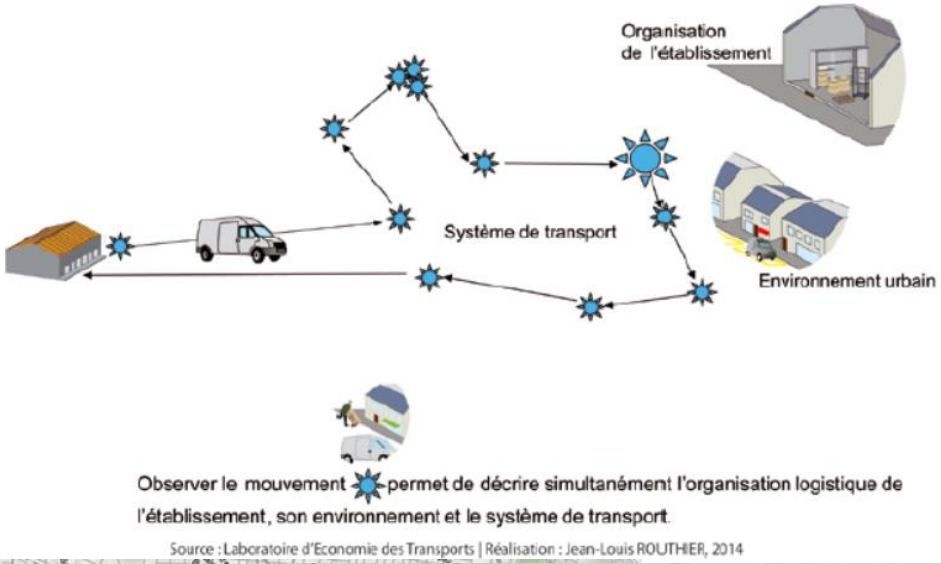
Survey methods: personal or telephone interviews, GPS data, electronic transactions

SOME EXAMPLES OF DATA COLLECTION METHODS (II)

Vehicle data survey

- Collects detailed information about the activities of a single vehicle (usually over a single day or a few days).
- Involves driver or operator recording trip and activity data.
- Provides data about exact locations served, route, arrival and departure times, time taken for delivery/collection/ servicing, type of goods/service, etc.

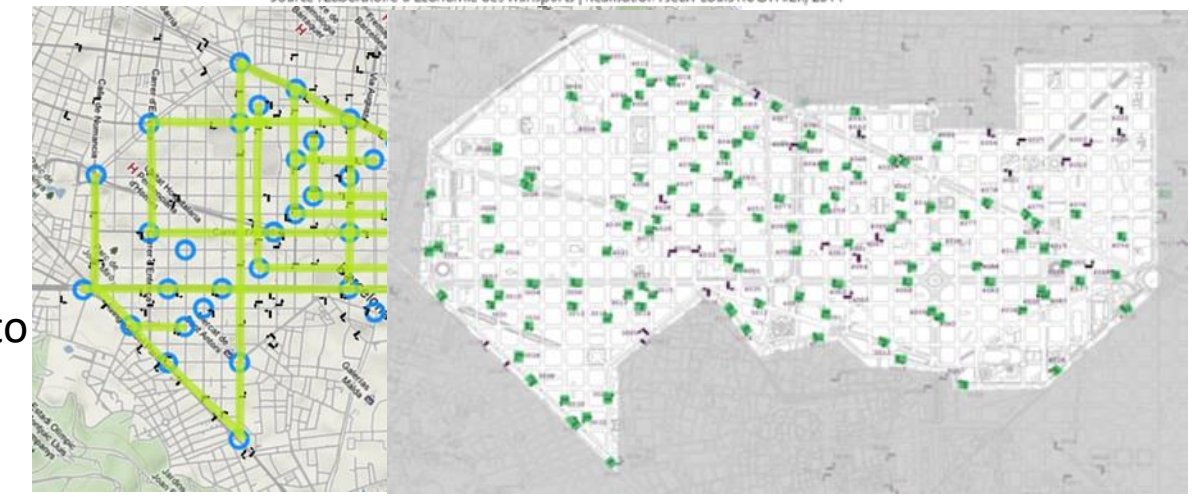
Survey methods: GPS vehicle tracking, electronic transactions



Vehicle traffic count survey

- Road vehicle traffic is counted and disaggregated by vehicle type.
- This provides details of the types of goods vehicles on selected roads or routes, or crossing specified cordons by time of day and day of the week. Includes all vehicles so as to be provide data on goods vehicles as a proportion of all traffic

Survey methods: City traffic surveillance system

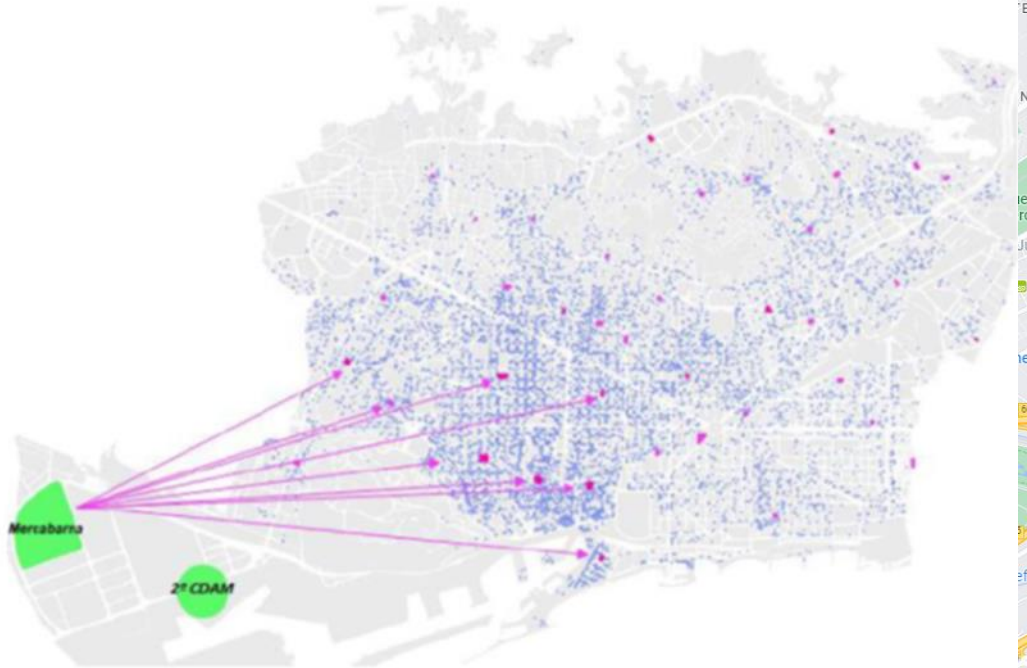


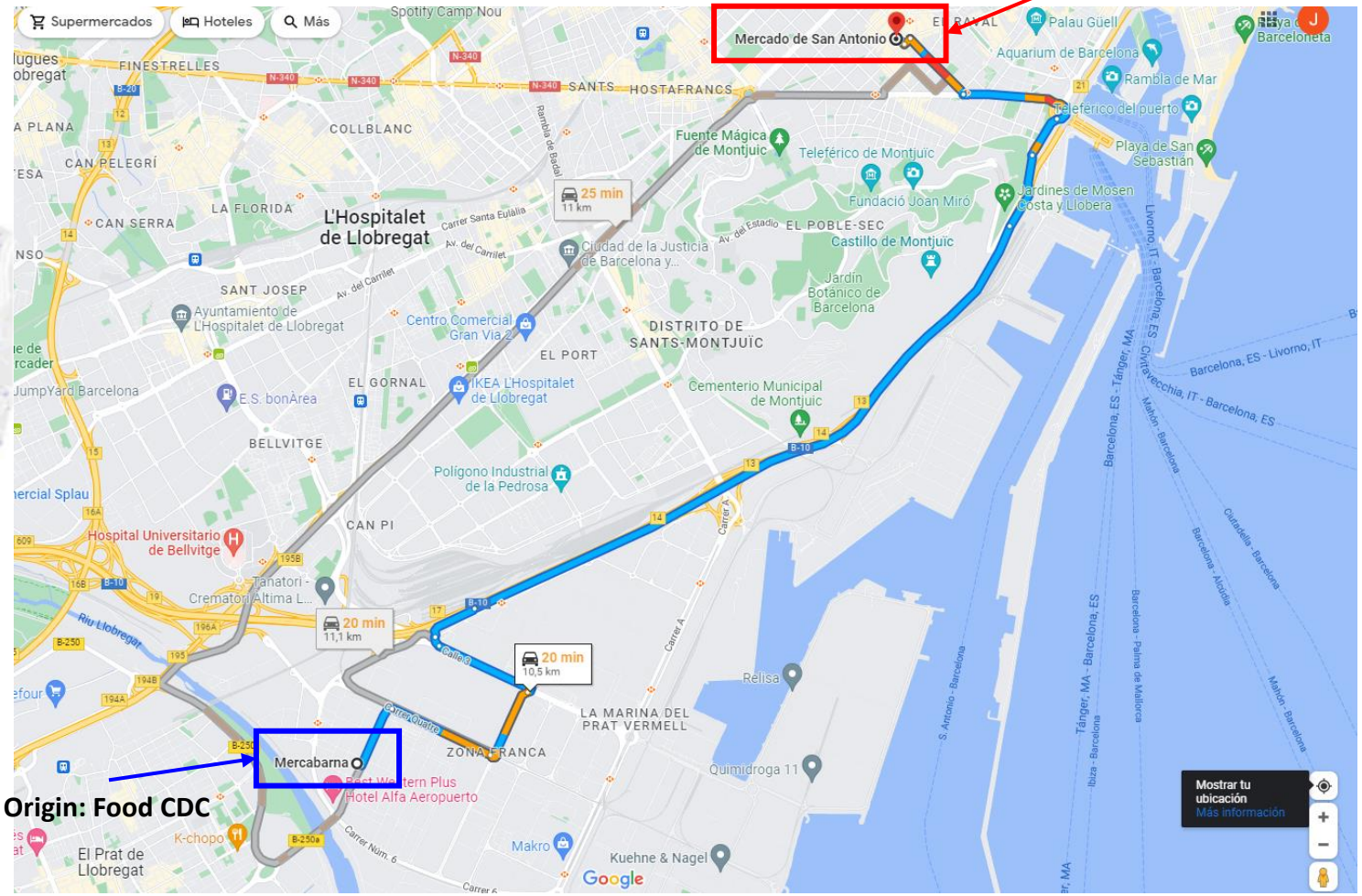
Barcelona's CBD: Traffic detection stations (Bluetooth & inductive Loops)

SUMMARY OF COLLECTED DATA: main characteristics of the tours

	Mean	Median	First quartile	Third quartile
Number of points	7,253	6,291	4,182	9,189
Number of delivery stops	21	15	8	25
Duration of a delivery stop (min)	17	14	12	19
Length of a route (km)	57	54	32	76
Duration of a route (hour)	4.27	3.70	2.45	5.38
CO_2 (g/km)	1,040	1,020	715	1,243

ACCESSIBILITY: A KEY CHARACTERISTIC





COMMENTS ON ACCESSIBILITY MEASURES

- The underlying goal of transport is about getting people to activities and getting goods to market. What we call 'accessibility'[(1)].
- Accessibility, as we mean it, measures the ease of reaching destinations[(2)].
- For planning purposes, assuming TAZ as data granularity unit,(1), a measure A_i of accessibility from TAZ i to the activities in an area S in terms of the TAZs j belonging to that area is given by

$$A_i = \sum_{j \in S} n_j f(c_{ij})$$

where n_j is the number of the considered activities (i.e. retail shops) in TAZ j, and $f(c_{ij})$ is a deterrence function, usually in terms of travel costs c_{ij} from i to j, of the form:

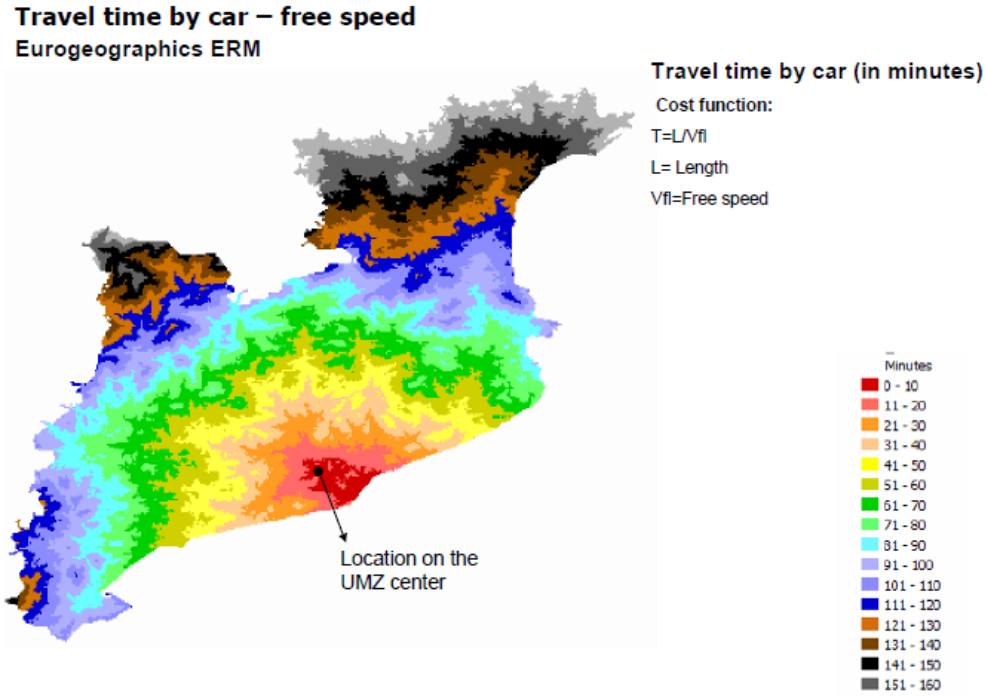
$$f(c_{ij}) = e^{\theta c_{ij}} \quad \theta < 0$$

- Another alternative, (1), instead of could be a global accessibility a_i^t for the whole Metropolitan Area from TAZ i in a time threshold t given by:

$$a_i^t = \pi \left[\frac{V_n t}{C_t}\right]^2 \rho_{act}$$

where V_n is the average network velocity (in Km/h), ρ_{act} is the number of activities per km^2 of the type considered in a circle whose center is the centroid of TAZ i, and radius the distance reachable during time t at speed V_n, and C_t is the "average circuitry", given by

$$C_t = \frac{D_{network}}{D_{euclidean}}$$



(1)Source: "Elements of Access". D. M Levinson, W. Marshall, K. Axhausen, NETWORK DESIGN LAB (2017)

(2)Source: Hansen, W. G. 1959. How accessibility shapes land use. Journal of the American Institute of planners, 25(2):73–76.

DESCRIPTIVE STATISTICS OF THE FREIGHT TOURS (WEIGHTED) ACCORDING TO THE TYPOLOGY

Variables	Desc. Stats	Heterogeneous goods					Homogeneous goods				Specific vehicles		Own-account consignee
		Deliveries / pickups			End-to-end	Line-haul	Food		Other				
		Parcels	Mixed	Pallets			Dry	Beverage	Fin. prod.	Interm. prod.	Fresh	Other	
Number of operations	**Ave.**	**29.9**	**10,0**	**4.2**	**3.6**	**2.7**	**14.7**	**9.5**	**13.3**	**4.3**	**10.6**	**1.4**	**2,1**
	StDev	22.1	5.2	2.3	3.4	1.6	8.4	3.7	10.4	2.8	5.8	0.8	3.7
Total distance of freight tour (km)	**Ave.**	**66.5**	**97.2**	**125.4**	**88.6**	**73.6**	**81.6**	**61.4**	**126.7**	**116.2**	**135.5**	**44.9**	**31,00**
	StDev	38.2	70.0	90.6	88.6	36.0	56.5	33.6	31.3	92.2	114.2	43.1	42.4
Distance travelled to and from the distribution center (km)	**Ave.**	**18.1**	**23.9**	**30.4**	**17.2**	**23.9**	**29.7**	**15.8**	**-**	**29.5**	**22.5**	**19.7**	**-**
	StDev	11.1	18.3	26.0	13.5	13.6	18.7	7.3	-	20.1	19.9	14.8	-
Total duration of freight tour (mn)	**Ave.**	**288.6**	**315.2**	**319.6**	**211.02**	**188.7**	**471.8**	**325.3**	**379.9**	**231.7**	**415.3**	**124.3**	**215.7**
	StDev	124.1	142.8	177.5	185.9	97.3	151.6	83.5	41.3	180.9	203.8	83.2	232.3
Average size of the vehicle (GVWR)	**Ave.**	**4.5**	**13.5**	**23.5**	**2.4**	**26.3**	**8.4**	**13.9**	**11.4**	**8.9**	**12.8**	**33.9**	**3.7**
	StDev	4.2	8.2	13.7	3.2	12.2	10.0	2.3	11.0	9.2	6.5	4.6	3.8
Average duration of operations (mn)	**Ave.**	**5.7**	**15.5**	**30.6**	**10.4**	**35.1**	**17.9**	**20.7**	**9.5**	**21.3**	**24.3**	**35.6**	**44.3**
	StDev	7.0	12.3	12.1	6.6	21.9	19.5	10.8	6.7	22.5	22.4	18.4	80.8
Number of tours obs.	-	38	91	15	44	21	78	43	28	56	72	28	32
Number of companies	-	19	16	8	12	5	17	4	21	12	16	3	26

Source: A. Beziat et al. (2015), Analysis of different types of freight tours according to their logistics organization in the Paris Region, IFSTTAR , Laboratory of Transport Economics

Name	Value of parameters	Type of variable	Definition
Constant	11.967 (8.76)***	-	-
Duration	0.016 (8.16)***	Control	Duration of freight tour (in minutes)
Turnover	0.003 (5.04)***	Company	Turnover of the company doing the transport (thousands of €)
Dist_Dest_ave	-0.085 (-3.09)**	Spatial	Average distance of the destinations of the trips of a tour to the center of the agglomeration
% prox activities	2.656 (2.60)**	Demand	The percentage of businesses reached by the tour which can be considered "proximity activities" (shops, retail, offices) vs. "basic activities" (industry, warehouses)
Mgt_mode_own account	-2.44 (-2.32)*	Company	Management mode of the company doing the transport operation (own account vs. third party)
Vehicle_rigid_truck	-3.506 (-3.61)***	Log. Org.	Rigid trucks, > 3.5 T (compared to light goods vehicles (< 3.5T)
Vehicle_artic_lorry	-6.184 (-4.79)***	Log. Org.	Articulated trucks, > 3.5 T (compared to light goods vehicles (< 3.5T)
Typo_mixed	-3.585 (-2.89)**	Log. Org.	Mixed bulking networks (compared to parcels bulking networks)
Typo_pallets	-8.285 (-4.94)***	Log. Org.	Pallets bulking networks (compared to parcels bulking networks)
Typo_end to end	-10.764 (-8.21)***	Log. Org.	End-to-end networks (compared to parcels bulking networks)
Typo_line haul	-6.888 (-4.05)***	Log. Org.	Line-haul transportation (compared to parcels bulking networks)
Typo_dry food	-2.324 (-1.40)	Log. Org.	Dry food distributors (compared to parcels bulking networks)
Typo_beverage	-4.600 (-2.42)*	Log. Org.	Beverage distributors (compared to parcels bulking networks)
Typo_fresh food	-5.779 (-3.91)***	Log. Org.	Fresh food distributors (compared to parcels bulking networks)
Typo_finished prod	-6.542 (-4.71)***	Log. Org.	Finished products distributors (compared to parcels bulking networks)
Typo_specific veh	-7.948 (-4.16)***	Log. Org.	Specific vehicles - cars and concrete (compared to parcels bulking networks)
Number of obs.	333		
R^2	0.5652		
Adjusted R^2	0.5432		

MODELING THE NUMBER OF OPERATIONS

$$Y = \beta_0 + \sum_{i=1} \beta_i X_i + \varepsilon$$

Source: A. Beziat et al. (2015), Analysis of different types of freight tours according to their logistics organization in the Paris Region, IFSTTAR , Laboratory of Transport Economics

ESTABLISHMENT STRATIFICATION

Group of activity	ST45 codes	Nomenclature of the activity stratum	No of establishments (IdF region)
Agriculture	1	Agriculture	10,293
Craftsmen	2-2	Craftsmen (repair)	4,421
Craftsmen	2-3	Craftsmen (manufacturing or installation	55,623
Craftsmen	2-4	Craftsmen (light repair)	4,782
Craftsmen	26Ha	Other tertiary sector (tertiary services: high flows)	38,939
Craftsmen	26Mi	Other tertiary sector (tertiary services: mixed flows)	123,418
Craftsmen	26Mo	Other tertiary sector (tertiary services: average flows)	7,299
Industry	3	Chemical industry	543
Industry	34-2	Construction industry (repairs)	2,025
Industry	34-3	Construction industry (manufacturing or installation)	19,870
Industry	4-2	Industry (goods of production and intermediate – basic bulk)	3,992
Industry	4-6	Industry (goods of production and intermediate – small objects)	6,599
Industry	4-7	Industry (goods of production and intermediate –bulk)	15,746
Industry	5-2	Industry of consumer goods (fragile foodstuffs)	232
Industry	5-4	Industry of non-consumer goods (fragile foodstuffs)	9,976
Industry	5-5	Industry of non-fragile consumer goods, equipment of the house and individuals	3,833
Wholesale	7-2	Wholesale (fragile intermediate products)	6,090
Wholesale	7-3	Wholesale (other intermediate products)	17,798
Wholesale	8-2	Wholesale (non-food fragile consumer goods)	671
Wholesale	8-3	Wholesale (non-food non-fragile consumer goods)	3,030
Wholesale	9-2	Wholesale (fragile food consumer goods)	879
Wholesale	9-3	Wholesale (other food consumer goods)	3,440
Department stores	10	Hypermarkets and big department stores	145
Department stores	11	Supermarkets	675
Department stores	12	Specialized department stores	804
Small retail stores	13	Minimarkets	1,750
Small retail stores	14	Retail trades, clothing, shoes, leather	17,493
Small retail stores	15	Butcher's shops	2,766
Small retail stores	16	Grocer's shops	7,150
Small retail stores	17	Bakeries – Cake shops	5,954
Small retail stores	18	Cafés, hotels, restaurants	52,591
Small retail stores	19	Pharmacies	4,304
Small retail stores	20	Hardware stores	1,232
Small retail stores	21	Furnishing shops	2,071
Small retail stores	22	Book shops	4,493
Small retail stores	23	Other retail shops	40,701
Small retail stores	29	Street trading (outdoor trading centers)	17,532
Offices	25	Pure tertiary sector (offices)	283,505
Offices	26Fa	Other tertiary sector (low flows)	27,414
Offices	27-2	Not tertiary offices (agriculture, wholesales)	3,755
Offices	27-3	Not tertiary offices (retail trade, industry, transport, administration)	1,608
Offices	6	Transport (except storage)	24,868
Warehouses	28-2	Warehouses (bulk)	1,480
Warehouses	28-3	Warehouses (of which transport)	1,666
Warehouses	30	Quarries	248
		Total	860,704

Source: F. Toilier et al. (2016) How can urban goods movements be surveyed in a megacity. The case of Paris Region. Transportation Research Procedia 12, pp. 570-583.

FORMULATION OF A TYPOLOGY OF PARISIAN MUNICIPALITIES

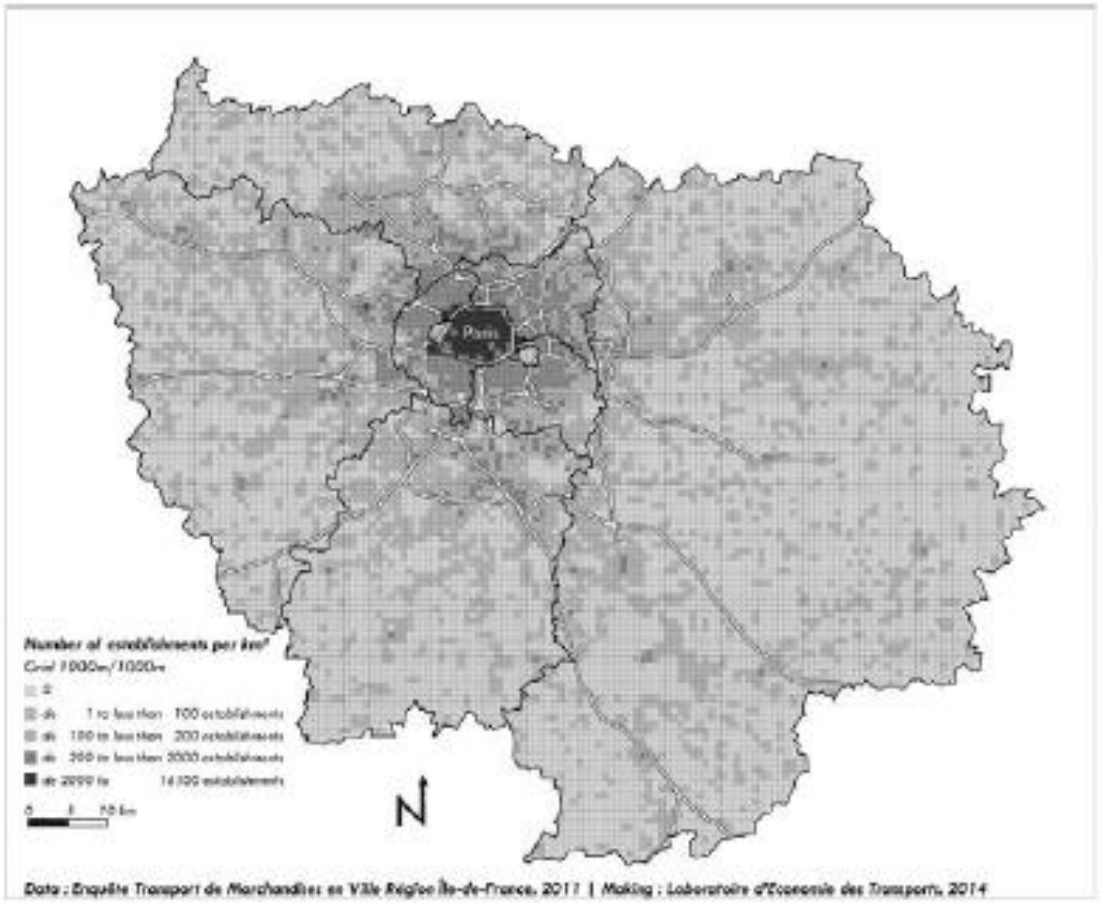


Fig. 3. Map of the density of establishments in the Île-de-France Region, Source: LET 2012.

A Principal Component Analysis (PCA) of 1,300 municipalities for the 15 variables below:

- Density (Population+Employment)/Surface area;
- Distance to nearest highway infrastructures;
- Distance to Paris city center (in km and average access time);
- Contribution (in % of flow per activity) of 8 main sectors of activity to goods flows.
- Land Use mode (relative share of properties in the municipality according to their use in % - file describing the land use of the Ile de France as a function of the type of building installed).

Table 2. The 9 types of area in the Île-de-France Region, Source: LET 2012.

Type	Name	Characteristics	No of municipalities	Surface area (km²)
1	High density	Dense, shops	75	341
2	Commuter belt	Non differentiated fabric	315	2,500
3	Commercial towns	Small retail	191	1,899
4	Industrial municipalities	Industry	93	976
5	Peripheral towns craft	Rural, craft	127	1,288
6	Predominance of wholesaling on outskirts	Wholesaling, industry	210	2,045
7	Predominance of large warehouses	Logistics activities	141	1,560
8	Green desert	Agriculture	122	1,221
9	Presence of hypermarkets	Hypermarkets	26	237
Total			**1,300**	**12,072**

Source: F. Toilier et al. (2016) How can urban goods movements be surveyed in a megacity. The case of Paris Region. Transportation Research Procedia 12, pp. 570-583.

TYPOLOGY OF AREAS OF THE ÎLE-DE-FRANCE REGION

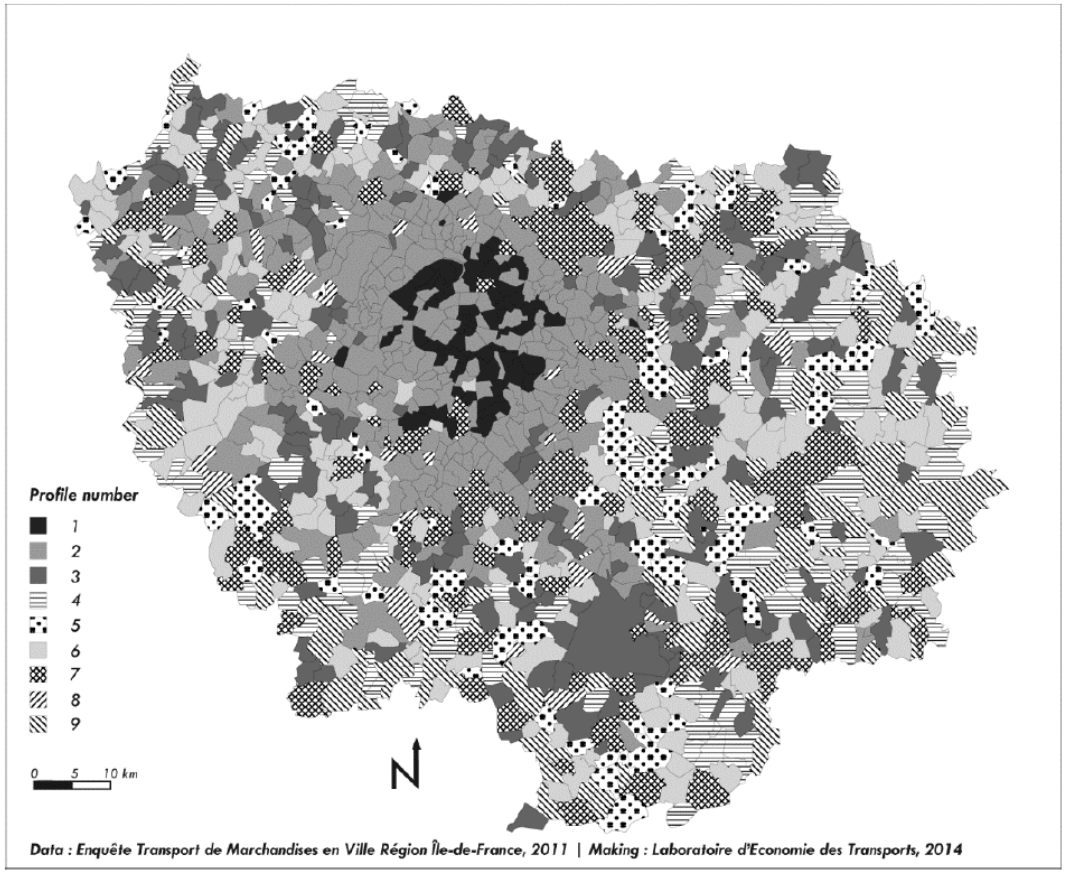


Table 3. Table of the goods transport characteristics of the urban typology.

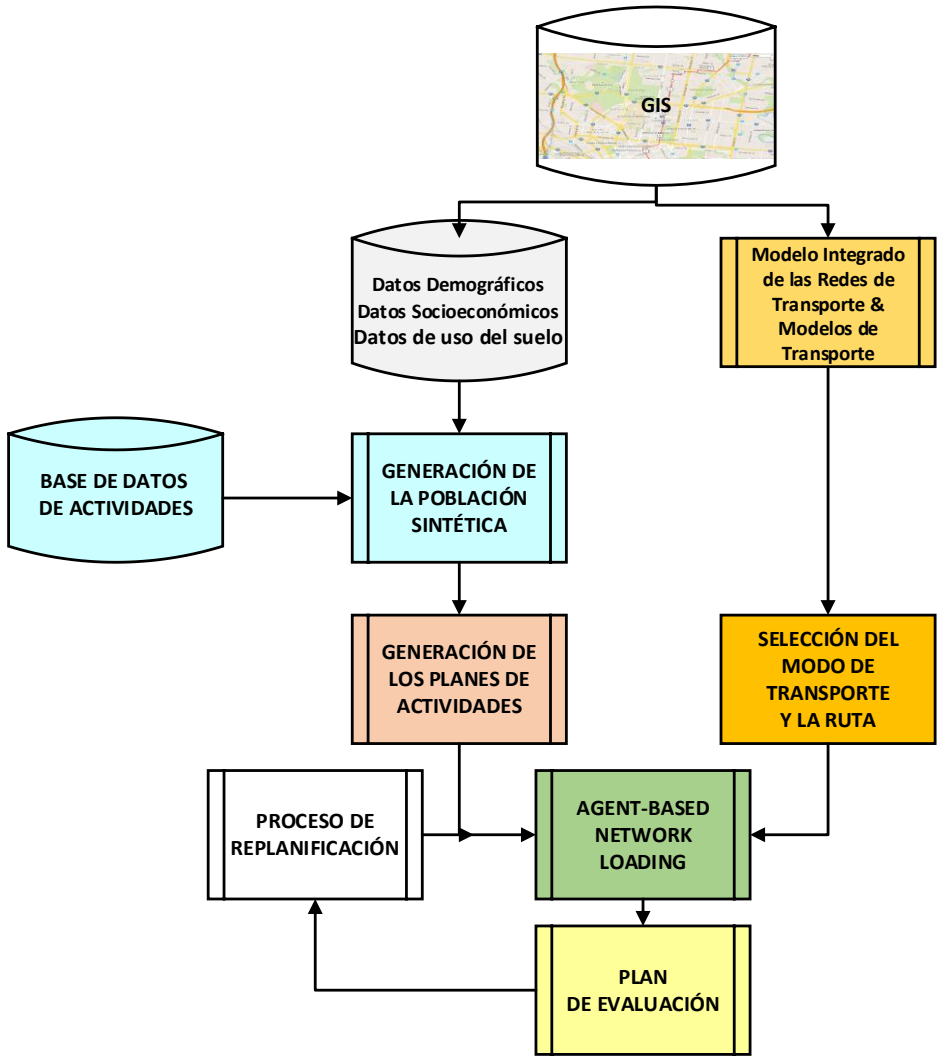
Type of activities	Urban typology profiles and goods movements characteristics									
	1	2	3	4	5	6	7	8	9	Total average
Agriculture movements	*0%*	*1%*	7%	7%	**12%**	9%	*3%*	**25%**	*1%*	7.0%
Crafts- services movements	27%	28%	35%	27%	**49%**	29%	16%	30%	22%	29.8%
Industry movements	12%	15%	8%	**37%**	11%	11%	11%	11%	9%	13.4%
Wholesale movements	21%	18%	*6%*	8%	*2%*	**30%**	17%	*2%*	15%	14.5%
Hypermarkets movements	2%	**2%**	*0%*	*0%*	*0%*	*0%*	1%	*0%*	**16%**	1.1%
Small retail movements	23%	24%	**30%**	13%	14%	11%	11%	10%	**30%**	18.2%
Offices	9%	9%	13%	8%	11%	10%	*5%*	**22%**	5%	10.4%
Warehouses movements	6%	4%	*0%*	*0%*	*0%*	*0%*	**37%**	*0%*	*2%*	5.6%

Table 4. Table of the general characteristics of the urban typology.

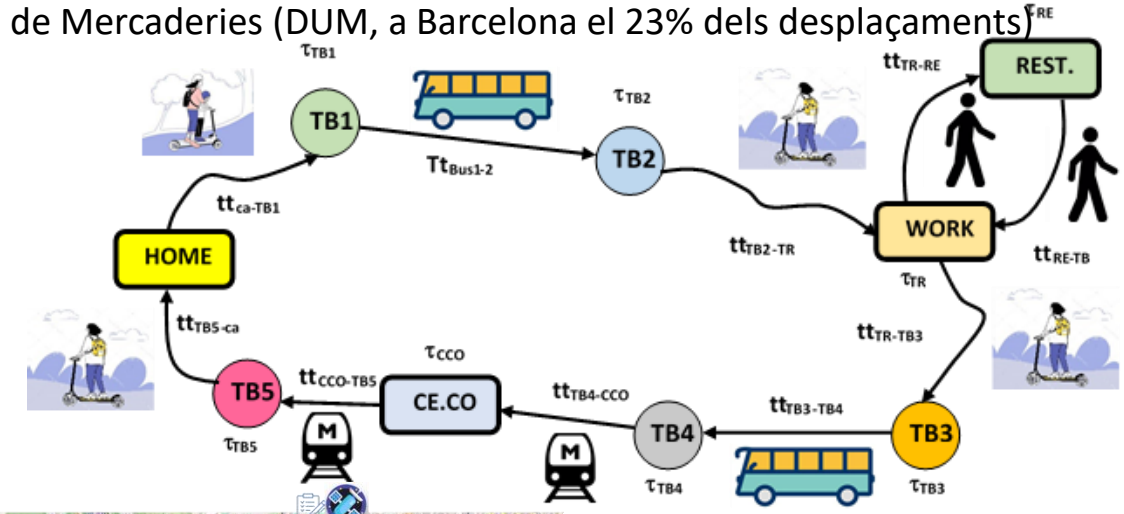
Characteristics	Urban typology profiles, geographical and accessibility characteristics									
	1	2	3	4	5	6	7	8	9	Total average
Distance to conurbation center	*10%*	28%	50%	52%	59%	51%	46%	66%	40%	44.3%
Distance to nearest motorway	*5%*	11%	24%	25%	**33%**	24%	17%	**39%**	16%	21.2%
Access time to nearest motorway	*2%*	4%	8%	8%	10%	8%	5%	**15%**	6%	7.2%
Density logarithm (population and employment)	**84%**	68%	46%	42%	37%	40%	50%	32%	57%	50.8%
Employment density logarithm	**75%**	**56%**	29%	27%	19%	23%	36%	*15%*	46%	35.9%
Population density logarithm	**85%**	70%	47%	42%	38%	41%	50%	33%	57%	51.6%

SUGGERIMENTS PER CONCLOURE I UN EXEMPLE

UN CAMÍ RECOMANABLE: MODELS QUE CAPTUREN MILLOR LA COMPLEXITAT (ACTIVITY-BASED MODEL/AGENT-BASED SIMULATION)

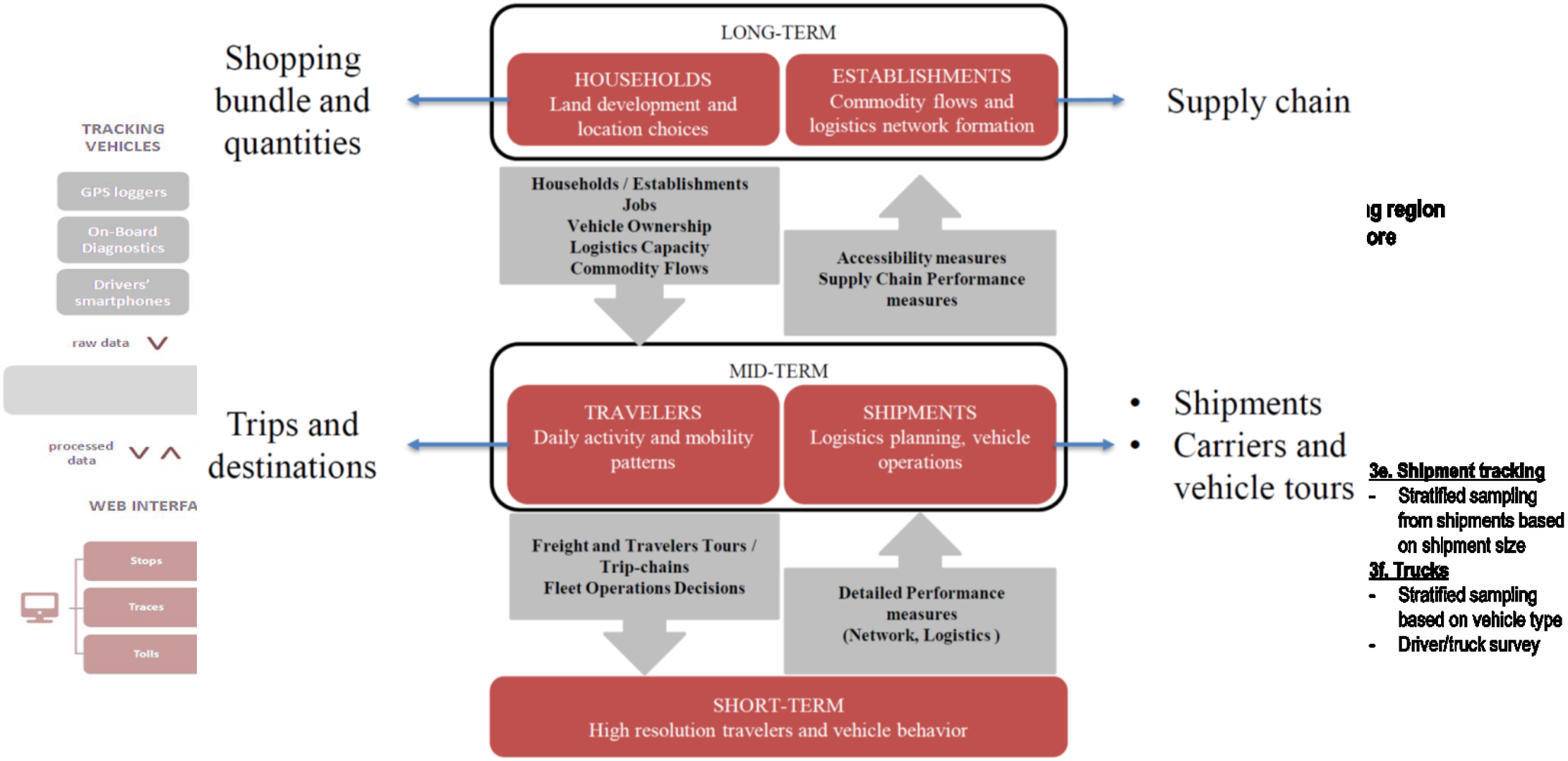


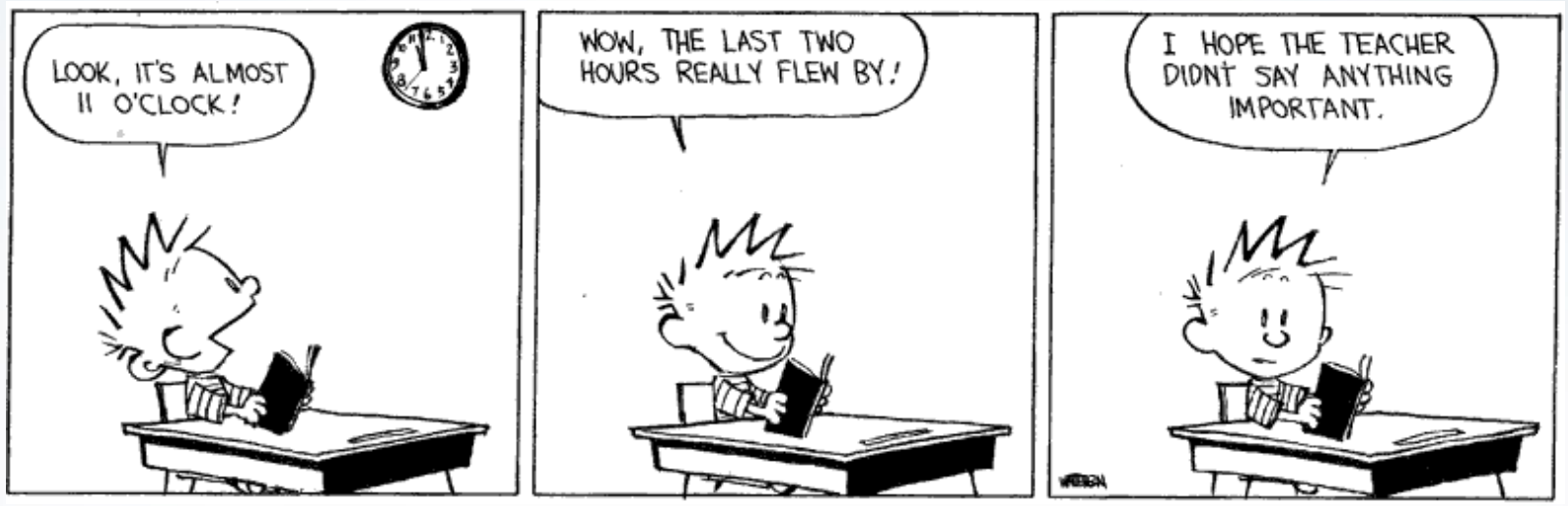
- **Models convencionals**: Models basats en viatges (4 Etapes), el viatge és la unitat d'anàlisi, els viatges els realitzen individus, tractats com a unitats independents i separades.
- **Estructura no adequada** per representar les decisions seqüencials durant el desplaçament (el viatge com a cadena multimodal) i les seves relacions amb d'altres.
- **No inclouen els fluxos** de trànsit induïts pels vehicles comercials a la Distribució Urbana de Mercaderies (DUM, a Barcelona el 23% dels desplaçaments)



Intensitat mitjana en dia feiner Barcelona 2018	Desplaç. Totals BCN	% Desplaç. VP BCN	% Desplaç. TOTAL
Turismes	1.174.483	55,94%	14,57%
Furgonetes (LDV)	394.591	18,80%	4,89%
Camions (MDV & HDV)	95.970	4,57%	1,19%
Ciclomotors	68.340	3,26%	0,85%
Motos	366.012	17,43%	4,54%
TOTAL "Vehicle Privat"	2.099.396	100%	26,04%

MODEL (SimMobility) INTEGRAT DE TRANSPORT I DUM DE LA CIUTAT DE SINGAPUR




LOOK, IT'S ALMOST 11 O'CLOCK!
WOW, THE LAST TWO HOURS REALLY FLEW BY!
I HOPE THE TEACHER DIDN'T SAY ANYTHING IMPORTANT.


thank you
danke
謝謝
ngiyabonga
شكراً جزيلاً
рахмат
teşekkür ederim
Баярлалаа
спасибо
gracias
dank je
tapadh leat
bedankt
dziękuję
obrigado
sukriya
kop khun krap
go raibh maith agat
arigatō
takk
dakujem
merci
terima kasih
grazie
merci
ευχαριστώ
감사합니다
তোমাকে ধন্যবাদ


Questions