Barcelona Virtual Mobility Lab

The multimodal transport simulation testbed for emerging mobility concepts evaluation

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***Abstract*—New sustainable mobility concepts and smart resilient ideas are arising every day. However, there is not an easy way to bring these ideas into reality, or to test how good they are as mobility solutions. Virtual Mobility Lab offers the opportunity to evaluate the impact of new mobility concepts before taking them to the real world. In this work, a multimodal macroscopic traffic simulation model of the Barcelona Metropolitan Area is developed, including both public and private transport network. This paper explains the remarkable features developed for this model, such as the network hierarchy and the multimodal public network interchangers, allowing demand to exchange between public transportation modes along their origin-destination paths.**

***Keywords*—multimodal; public; transport; network; macroscopic; traffic; simulation; model**.

I. INTRODUCTION

Nowadays, changes in urban networks and proposals of new mobility concepts are not easy to evaluate. They cannot be assessed directly in the real life, either due to the unknown effect on the real traffic or due to new infrastructures that are not yet built in the city. An option is to apply a pilot test, but it is often difficult, expensive and hardly configurable. Another option simulates the impact of the change or proposal applied to the real environment.

The simulation is used in many contexts in order to measure, in a virtual environment, the impact of applying modifications on the real-world. It requires a previously developed model that represents, as precise as possible, the key characteristics and behaviors of the selected real scenario. In this case, any new mobility concept that wants to be tested should be recreated first in a simulated scenario, instead of spending time and money evaluating it with real fleets in the streets (if possible) [1][2]. In order to perform a good transport simulation, it is necessary to develop a model that represents accurately the real transport network. For this, it is important to have knowledge about the real scenario, as for example the multimodal details, a well-defined network hierarchy and an updated information of the public transport system.

Thus, this paper presents the Barcelona Virtual Mobility Lab (VML), which uses a multimodal macroscopic simulation model developed in inLab FIB at Universitat Politècnica de Catalunya using PTV Visum Platform [3]. This project models a transport system to assist in the design and evaluation of impacts of new mobility concepts.

The paper is organized as follows. Section II describes how the study territory area is divided and Section III and IV explain how private and multimodal public transport networks have been modeled, respectively. For Section IV, some indicators obtained from the model are described in addition to some guidelines of how the built model can be exploited on its potential applications. Finally, the document shows some final conclusions.

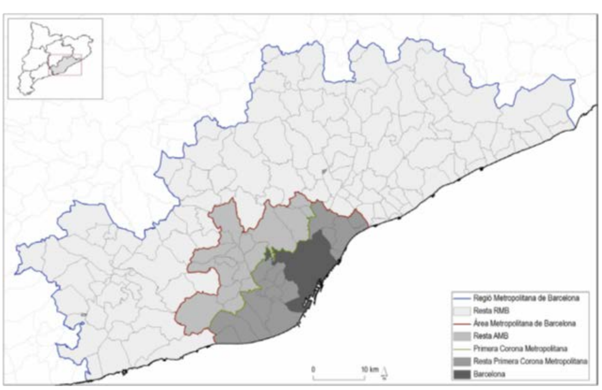

Figure 1. Areas of metropolitan region of Barcelona.

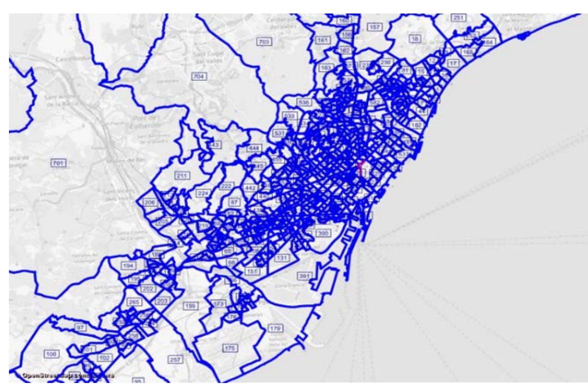

Figure 2. Zoning system of the study area.

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II. STUDY AREA ZONING SYSTEM

The study area included in this model is identified as the first crown of the metropolitan area of Barcelona. This area (delimited by the green line in Fig. 1) is composed by Barcelona city and 17 municipalities placed around it and they represent a population of more than 2.8 millions of people.

Zoning system divides the study area into homogeneous Transport Analysis Zones (TAZ) according to socioeconomic features and access to transport facilities. Demand matrices model the number of trips between TAZ zones. In the zoning system, the area is represented by 628 zones that cover the study area and the contiguous territories (identifiers from 700 in Fig. 2).

The used demand data is provided by KINEO [4] who uses mobile phone data to extract the origin, destination and trip time tags. The demand is represented separately by hourly Origin to Destination (OD) matrices. This allows studying the different situation of the transport network depending on the time of the day.

III. PRIVATE TRANSPORT NETWORK

The private transport network is the representation of the urban network geometry. In order to simulate the behavior of the private vehicles in the network, it is needed to model a road network and their private transport systems. In traffic simulation modeling, the network geometry is usually constructed street by street to obtain a first model. This is a hard work task since even for small traffic models can have thousands of streets.

This methodology is not a feasible solution for such a huge metropolitan area, thus geographical maps from HERE [5] have been imported into the platform to simplify the model building process. It also imports the available transport system in the modeled area for private and public transport (imported from General Transit Feed Specification (GTFS) files [6]).

To support this, the traffic simulator VISUM allows a fast transport network modeling through HERE Maps to obtain a first approach model. The updated road network from HERE has been imported to VISUM that generates a traffic model with all the nodes and links (Fig. 3).

This procedure helped to construct a first network model, but there are more concepts that needed to be modeled like the representation in detail of the road network hierarchy. This hierarchy created to distinguish between transport road types is shown in the Table I.

This allows to model different types of streets depending on the speed limit, number of lanes, etc. in the road network for each of the transport systems (e.g., if allowed, the velocity limit, etc.) in a general mode. Then, manual edition of network characteristics imported from HERE maps has been done for specific areas.

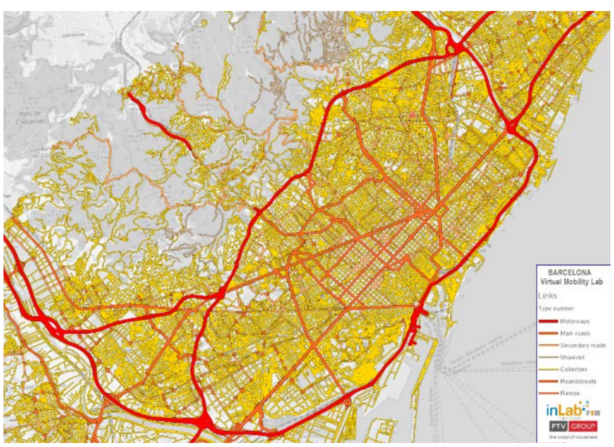

Figure 3. Private vehicle network road hierarchy.

IV. MULTIMODAL PUBLIC TRANSPORT NETWORK

As mentioned before, a multimodal network allows generating OD paths exchanging public transport modes when doing a demand assignment. In our model we considered the following modes:

- Train
- Underground
- Bus
- Tramway

Accordingly, building a multimodal public transport network implies introducing all these modes and, for each of them, all the transport lines (e.g., Fig. 4 and 5). For this, it is necessary to know the topological route of each line, the number of stops, which sections have reserved lines in case of buses, and the number of travels each day

TABLE I. PRIVATE VEHICLE NETWORK ROAD HIERARCHY

Type Name	Lane-capacity per hour	Free-flow Speed (km/h)
Motorway	1500	120
Urban motorway	1200	80
Coordinated Arterial (Aragó)	900	50
Uncoordinated Arterial	650	50
First Level Collector	700	50
Secon Level Collector	500	50
Road	800	80
Street without Traffic Lights	300	40
Unpaved rural road	100	30
Side/Access Lane	600	40
Roundabout	350	40
Bike	100	15
Pedestrians	60	5

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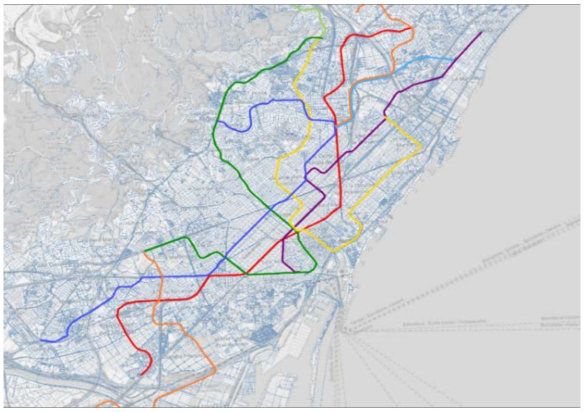

Figure 4. Public Transport network: underground.

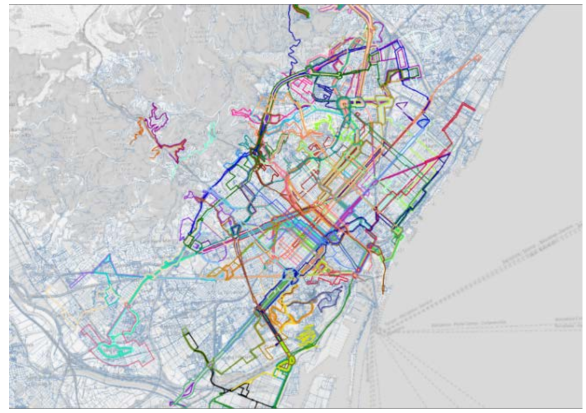

Figure 5. Public Transport network: buses.

considered: headway based journey based on frequency. For this macroscopic model, frequencies were used to model public transport services, adjusted to current transport operators.

One of the main peculiarities of this macroscopic model is the approach of joining these transport modes. To achieve this, some logical components were introduced: *stop points*, *stop areas* and *global stops*:

- *Stop points* define the topological position in the private network (urban map) where a station or bus stop is located.
- *Stop areas* are useful for grouping stop points that lead to the same public line (e.g., an underground could have more than one entrance to the platform).

Global stops gather all *stop areas* where it is allowed to perform transfers between different transport modes (blue circle in Fig. 6). Changing costs between lines or modes can be configured in these *global stops* (Fig. 7).

V. RESULTS

Just having into account the integration of all transport modes with almost all operators is a magnificent achievement, especially considering the context of Barcelona's network complexity. As a result, the macroscopic model obtained is the unique intermodal built until now with all transport modes.

The methodology followed to build the Barcelona VML model can be applied to any other model building process for other geographical areas. The Barcelona VML model also can be extended. Portability and extensibility of multimodal models through the proposed methodology is a trustingly success key. The model can be applied to other cities and also can be extended to larger areas.

Also, accurate model calibration has to be taken into account in following working steps to obtain a stunningly realistic model. This implies collecting real data to validate measurements from the model and contrast them with reality (e.g., data from counting sensors vs results from an assignment). The more data sources implied in the calibration process, the better for the model's accuracy. Besides that, on the early first version of the model (without any accurate network refinement), public and private transport assignments brought to light very reliable results (assignment results shown in Fig. 8 and Fig. 9). To perform this calibration, more real data from business key partners is needed, such as direct network measurements in the real world.

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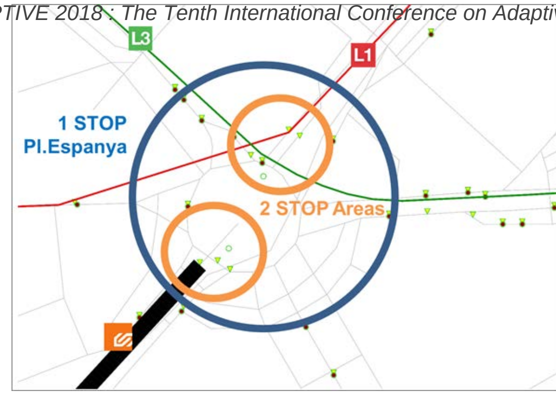

Figure 6. Modelization of Pl. Espanya Multimodal Transfer Area.

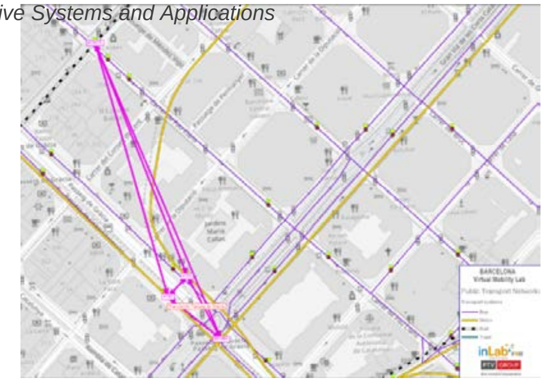

Figure 7. Modelization of Pg. de Gràcia Multimodal Transfer Area.

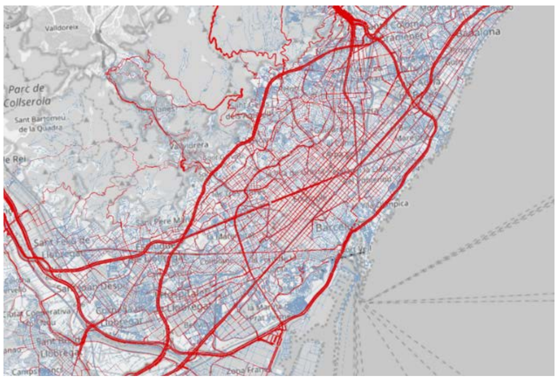

Figure 8. Private transport assignment 8h - 9h.

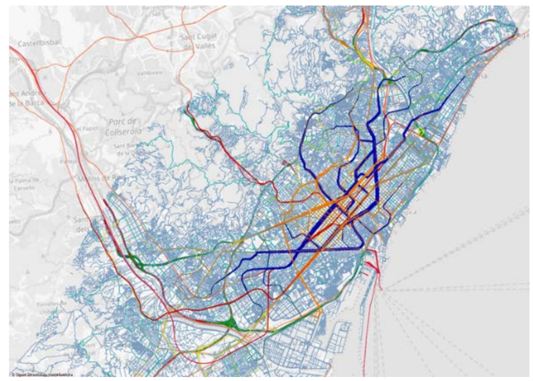

Figure 9. Public transport assignment 8h - 9h.

VI. Applications

The developed simulation model offers a lot of possibilities in order to correct, to update and to improve the mobility scene of the contained scenario. It allows studying how the current mobility plan is working, identifying the demand patterns and how they evolve and, detecting possible shortcomings in the current or future system. This information helps public organizations to take political decisions about the future modifications in the city mobility plan. Beside public organizations, the public transport operators can also take advantage of a complete vision of the scene and apply improved action plans depending on the demand behavior.

With regard to this panorama of smart mobility, this model can be very useful for evaluating new concepts or ideas, as well as having a complete analysis of all possible parameters involved, before launching them to the real world.

VII. Conclusions

The Barcelona Virtual Mobility Lab is the first detailed multimodal model of the Prime Crown of the Metropolitan Area of Barcelona. It integrates all modes of public transport as well as the private vehicle roads that would support future projects in traffic design and planning. A systemic scope consisting of all transportation modes and services is the added value of the developed model.

The next step will be to calibrate the model. Otherwise, it will not be useful as a Decision Support System tool. The model will help supporting future scenarios involving new transportation modes, vehicle types and urban developments.

Acknowledgment

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