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Monitoring urban accessibility for freight delivery services from vehicles traces and network modelling

Miriam Pirra[a]*, Angela Carboni[a], Francesco Deflorio[a]

[a]*DIATI, Politecnico di Torino, Duca degli Abruzzi 24, 10129 Torino, Italy*

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1. Extended Abstract

Freight distribution in cities is increasing its role in road traffic, also for the internet shopping growth which is partially substituting the traditional customers goods purchasing. In 2016 the Italian e-commerce market was 19.6 billion, with a 18% growth compared with the previous year (Freight Leaders Council, 2017). As a result, goods need to be delivered directly to individual consumers, who live spread into the city, instead of arriving in bulk to selected store locations. This has an impact on the pattern of the goods transport demand, in particular on urban freight transportation, which includes the traditional shops deliveries. In cities usually affected by critical traffic conditions, high levels of urban freight activities may create additional problems in terms of congestions and environmental impacts. As confirmed in a recent study, deliveries have a significant impact on urban traffic in terms of congestions since they account for about 10-15% of kilometers travelled (CIVITAS WIKI consortium, 2015). More specifically, in Europe around 25-30% of the urban deliveries are carried out through light vans, hence the study of their activities in cities (e.g. by their recorded traces) could provide useful information about freight traffic trends (ALICE and ERTRAC, 2015). At environmental level, recent analyses reveal that "in Europe urban freight is responsible for 25% of urban transport related CO_2 emissions and 30 to 50% of other transport related pollutants" (Meyer and Meyer, 2013).

Public Authorities are experimenting policies to control and manage the access in city center, with the expected aim of reducing air pollution, as well as to protect and enhance the historical center and monitor the land use. Such measures can be managed in the framework of SUMPs (Sustainable Urban Mobility Plans), available planning tools that are becoming mandatory for cities and metropolitan areas in European countries. The evaluation of such policies and their effects for users and stakeholders should be assessed, in current and alternative scenarios, by specific and measurable indicators. This monitoring part of the planning process and the impact of the implemented measures for city mobility is fundamental to promote actions which effectively contribute to the achievement of the expected benefits.

The aim of this paper is to develop a method to measure the city accessibility for freight distribution services by the use of vans GPS traces. The accessibility was investigated through the travel time estimated along the most frequently used paths and the average speed to connect relevant zones in the city. In our framework "accessibility" could be defined as the ease and extent to which road network enable deliveries vehicles fleet to reach the various

* Corresponding author.
E-mail address: miriam.pirra@polito.it

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zones of city. On the whole, a variety of methods have been developed for measuring accessibility including infrastructure-based, location-based, person-based and utility-based measures (Cui et al., 2016). The approach chosen for our study can be categorized as location-based by using travel time and speed of a set of vehicles, estimated by a selection of their positioning data. The proposed method can be exploited by public authorities to analyze the current network performance for freight delivery and planning future measures (e.g. reserved lanes, network regulation), but also by operators as support to decision in choosing the time to delivery shifting from congested to off-peak periods. To reach this objective the raw data chosen for this methodology were van GPS traces thanks to their targeted information value, compared to their easy availability to be obtained. The creation of more efficient and sustainable urban transport and logistics networks has been promoted through a number of projects in Turin (Italy) such as PUMAS and NOVELOG (http://novelog.eu/). Moreover, the city created a set of 'push and pull' measures combining both incentives and restrictions for those operators that follow Freight Quality Partnership (FQP) Agreement in their delivering. Most of these measures aim at reducing and rationalizing the deliveries in the city center, which is characterized by a limited traffic zone.

The method is based on a dataset collecting more than 360,000 GPS positions in Turin related to vehicles (light vans) belonging to logistics fleets delivering goods all around the city. More in detail, GPS traces are collected for 28 different vans in a period going from 29th April to 29th May 2017. Each recording includes time and day, latitude and longitude, instantaneous velocity and bearing. Only GPS traces collected in working days are included in this analysis.

To map the accessibility in the selected study area a preliminary sketch network model was built by selecting principal nodes and links using a traffic modeling tool for a high-level representation (*a priori* network). This network contains 408 links[†] (324 arcs and 84 connectors), 110 nodes and 18 centroids. Only two main types of links are defined to simplify the network handling:

- "Motorway" which includes the links of the urban motorways. The speed setting is 80 km/h according to the authors' experience on the average speed during congested periods for this road typology.
- "Road2lanes" which includes all other links. The speed setting is 30 km/h to consider the presence of secondary intersections along the link affecting traffic conditions.

One internal centroid is located in the Turin city center, whereas the external centroids are 17 and are chosen according to their relevance in terms of connections with the urban network including the A55 Turin Ring Road for its relevance for freight distribution vehicles (**Fehler! Verweisquelle konnte nicht gefunden werden.**).

Each node of the *a priori* network is used to detect the instant when any vehicle crosses it and therefore the travel time along the corresponding links. To increase the chance of vehicle detection at nodes, these have been set with different diameter options depending on the link type, to adapt the detection inside the node to the expected vehicle speed and the sampling rate of GPS data (Figure 2). These first analysis concentrate on the traces registered in the time range 9.00 - 12.30 a.m. to capture a larger number of vehicles circulating and to refer the estimated speed to a homogeneous period. The classification of links has been refined using the average speeds on the links with at least 10 measures (38 links). The decreasing trend of these speed values was used as support to define 5 new classes of "road_types" and the corresponding average travel speeds are as following:

- "Type1" → 120 km/h
- "Type2" → 105 km/h
- "Type3" → 58 km/h
- "Type4" → 29 km/h
- "Type5" → 10 km/h

The final network, called *a posteriori*, is derived from the refinement of *a priori* one thanks to the GPS traces dataset that allow a better definition of the links characteristics previously defined. The classification, as an alternative of assigning the specific speed estimated to each link, is an approximation that allows a better

[†] All are two-way links

management of the model and has a negligible loss of information, with respect to the travel time estimated between zones.

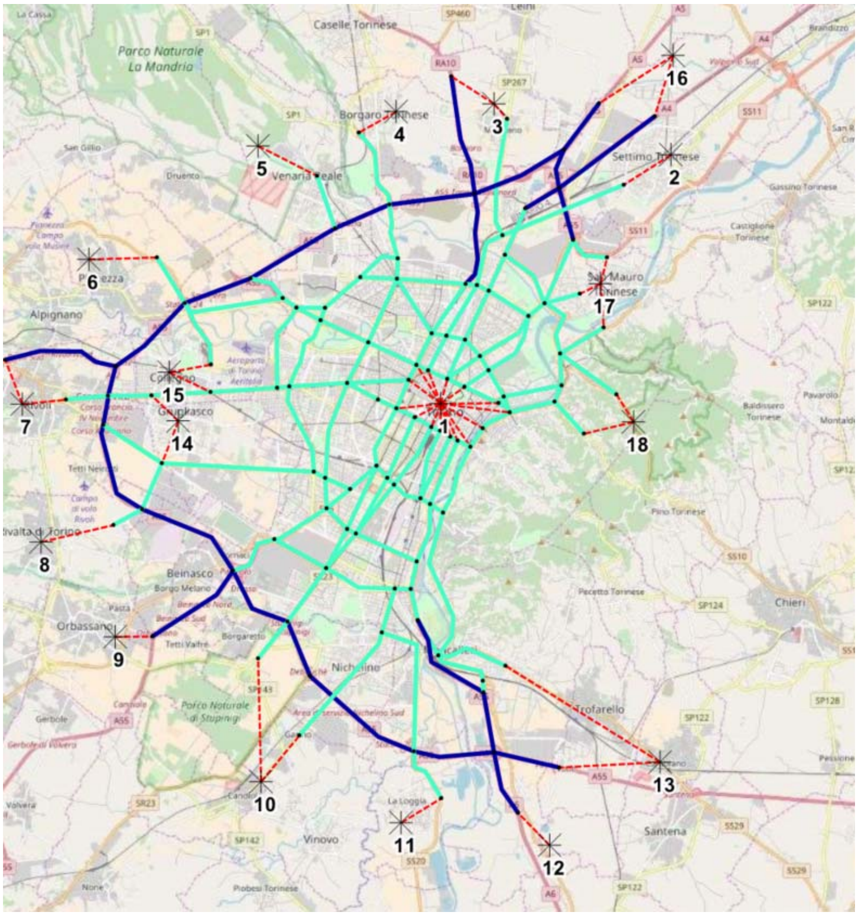

Figure 1 *A priori* network of Turin area (Motorway in dark blue, road2lanes in light blue and connectors in red line)

(a) (b)

Figure 2 Two examples of different diameter options for the matching between nodes and positioning data: a two lanes road (a) and a motorway case (b).

The main results underline how Floating Car Data (FCD) integration on the travel time matrices could improve the knowledge of the road network performances to help different stakeholders providing them reliable feedbacks according to their specific needs and interests. These high-level accessibility matrices could be applied to compare different zones of the city interested in delivery operators or to analyse the most used urban connections to better define policies and more targeted actions. Moreover, these first results are closely correlated with a specific kind of data analysed, namely light duty vehicles traces, and they depict a well-defined situation that could be certainly informative for a clear-cut kind of stakeholders, as urban logistics operators. In such frame, future works could try to integrate these findings with the availability of areas of the city where deliveries are operated. In addition, the availability of a larger database, including GPS traces of wider classes of vehicles, could help in deepening the knowledge of the network.

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