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Procedia - Social and Behavioral Sciences 111 (2014) 360 – 369

Procedia
Social and Behavioral Sciences

EWGT2013 – 16th Meeting of the EURO Working Group on Transportation

A state-of-the-art modeling framework to improve congestion by changing the configuration/enforcement of urban logistics loading/unloading bays

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Abstract

Systematic ways to perform ex-ante analysis of urban freight good practices are still missing, deeming transferability efforts prone to failure. We critically analyze state-of-the-art freight modeling methodologies to optimize the configuration of loading/unloading bays, and the associated enforcement measures, quantifying congestion reductions. Existing models can poorly handle some crucial elements for this analysis. An alternative modeling framework is proposed, integrating simulation models and optimization strategies that take into account double-parking derived vehicle obstruction. The framework should lead to deeper insights, even in a low-data availability perspective, between what is regarded as good practices and a quantification of their potential; thus becoming a useful tool in the design and analysis of policies.

Selection and/or peer-review under responsibility of Scientific Committee

Keywords: Urban freight; City logistics, Modelling framework; Loading/unloading bays; Enforcement; Double parking; Congestion.

1. Introduction

Urban freight is defined as the set of activities that, within the boundaries of urban areas, include any kind of delivery, pickup or transfer of physical goods and, in some cases, the provision of services. Alternative definitions can be found in Allen et al. (2000) or Muñuzuri et al. (2009). Albeit there is a significant overlap, in the literature a distinction is made between the concepts of urban freight and city logistics. City logistics has

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1877-0428 © 2013 The Authors. Published by Elsevier Ltd.
Selection and/or peer-review under responsibility of Scientific Committee
doi:10.1016/j.sbspro.2014.01.069

been defined by Taniguchi et al. (2001) and Geroliminis and Daganzo (2005), with a strong focus on the optimization of urban freight operations. Dezi et al. (2010) have also defined what is considered as an optimized logistics scenario, pointing towards the *"satisfaction for stop demand and the rationalization of the operations of delivery/pick-up in respect to road safety, traffic rules and the environment at large"*. A way to organize, and optimize, loading/unloading operations is to provide an adequate number of on-street, public, loading/unloading (l/u) bays; properly located and sized to the freight vehicles that might use them. The simulation of urban freight operations related to the usage of l/u bays can encompass a variety of activities such as:

- vehicle paths to and from depots to l/u bays and/or establishments;
- drivers walking from l/u bays or other parking locations to establishments;
- vehicle routes within delivery rounds/tours, between l/u bays and/or establishments.

The simulation of such activities might include the interaction between parked and circulating vehicles. Legal, on-street, parking usually adopts one of the following configurations: horizontal, diagonal or perpendicular with the traffic lane. Due to the scarcity of l/u bays, or to an inadequate spatial configuration, double parking is a common practice (Dezi et al., 2010; Muñuzuri et al., 2012). Note that this phenomenon is not exclusive, but quite common, to freight vehicles. When confronted with a double parked vehicle blocking the lane, the driver must often perform a "taking over" type of trajectory, usually with some loss of speed (Geraldes, 2004). A way to deter this behavior is to enforce parking rules (Ishida et al., 2006; Muñuzuri et al., 2006).

Based on the above considerations, we propose that the l/u bays optimization process should consider the following factors: location, size, and number of bays, as well as correct usage enforcement. We also propose that obstructions derived from double parking should be analyzed considering both spatial and temporal components. Furthermore, the combinations of these components characterize the spread capabilities of the obstruction.

Spatial obstruction is related to a change in trajectory that vehicles must perform to overtake a double lane parked vehicle. This obstruction is hypothesized as being dependent on:

- the number of vehicles that are double parked;
- the position of the double parked vehicles in the road section;
- the characteristics of the road (i.e., number of lanes, dimension of lanes, existence of traffic lights).

A very high degree of detail is needed to adequately represent these situations in a micro-simulation framework, especially regarding the vehicle trips and lane configuration as these elements impact on the type of obstruction: vehicles could be just slowing down the flow or even stopping other vehicles. The temporal component, that is the duration of the obstruction, can be assumed as equal to the duration of the parking activity. The spread of obstruction regards the cumulative obstruction of vehicles spatially and temporally. It can be represented by the total number of vehicles obstructed at the same time.

There are four main references in the literature that tackle the issue at hand, but they do it from different perspectives (see Table 1). We also point out the drawbacks that can be found in the application of the respective four models. Aiura and Taniguchi (2006) assumed freight vehicles do not park illegally which is far from the reality in many cities (Delaître, 2009; Muñuzuri et al., 2012). Also, modeling is only done for one street as the micro-simulation is too demanding (computationally and data-wise) for larger geographical areas.

Delaître (2009) does not take into account the situation when the delivery area is occupied by a private vehicle, which is also far from the reality (Aiura and Taniguchi, 2006). His model is relatively limited as it cannot provide a calculation on the time lost for individual vehicles due to (temporal) obstructions, and it cannot propose a better location for l/u bays.