Dassia: A Micro-Simulation Approach To Diagnose Urban Freight Delivery Areas Impacts On Traffic Flow

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Abstract: In this paper we develop an approach (DASSIA: Delivery Areas Scenarios Simulation Approach) to analyse the impacts of urban freight delivery areas on traffic flow using microscopic simulation. The objective is to reproduce urban freight movements particularly concerning double-parked delivery operations. In the first part, we proposed our methodology for assessing the impacts of the implementation of urban delivery areas on the traffic flow. A comparison of the tools developed for micro-simulation traffic is reported in order to choice our simulation tool. In the second part of this paper, the simulation results show that the delivery areas zones directly influence the traffic flows and the tool allows a representation of the reality and is specified and calibrated in a commercial street in Morocco.

Index Terms: Assessing, Delivery areas, Microscopic simulation, Traffic flow, Urban freight transport

1 INTRODUCTION

Urban freight transport (UFT) is becoming increasingly important in the urban mobility strategy because it generates higher costs by increasing congestion, pollution and noise. As a proportion of traffic flows, the delivery operations movements influence road occupancy and safety and thus reduce the quality of life in the city [1], [2]. As the importance of the UFT increases several authors have explored best practices and organization schemes for improving the performance of the urban freight in terms of cost, traffic congestion, logistic efficiency, environmental nuisances, or other criteria depending on the stakeholders taken into account. Among the operational measures to improve the circulation urban freight transport, delivery areas represent an opportunity for the organisation of deliveries and the improvement of road traffic flow. Therefore, this paper aims to develop a microsimulation framework for studying the impacts of the implementation of urban delivery areas on the traffic fluency. The article is divided into two main parts. In the first part, we propose the methodological framework used to study the impact of the location of delivery areas on urban traffic. We addressed a comparison of traffic flow simulation tools. A real representation of the simulation results in the case of a commercial street in Morocco is explained in the second part of this work.

2 BACKGROUND

There are many authors in the literature that focus on identifying best practices in the location and improvement of delivery areas. An hybrid model was developed in order to help local authorities in location of delivery areas taking into account the impacts on the global traffic flows. Two modules compose the proposed tool: a simulation of delivery areas at local level based on queuing systems and a simulation of the overall traffic spread [3]. The concept of delivery areas in the case of a shopping street was studied in [4]. They proposed a number of operating scenarios based on punctual deliveries and pickups, using a comprehensive database of UFT traffic and parking conditions. In addition, [5] assessed the impact of changing the number and location of delivery areas on the level of illegal parking practices. Also, [6] have developed for the case of the city of Seville, a model for optimizing the location of delivery spaces by evaluating the effect on the cost of the delivery system. In the same sense, [7] have developed a model for assessing and optimizing the location of delivery areas based on meeting the logistical needs of commercial establishments associated with the frequency of goods movements generated in the study area. They proposed a model to sample the arrival intervals and service times of trucks using these areas. Finally, [8] proposed, in their project Future Delivery Area, a new concept of operation of delivery areas based on the principle of prior booking by delivery drivers managed by a delivery information system. The same principle has been studied by introducing the environmental parameter within the reservation of delivery areas [9].

3 DASSIA: PROPOSED SIMULATION FRAMEWORK

In this section, we expand the DASSIA approach developed in order to analyse the impacts of urban freight delivery areas on traffic flow using microscopic simulation. (Figure 1). The developed framework is structured around three phases: a preliminary phase allowing the preparation to the realization of the model and the calibration of the data collected according to the input parameters of the simulation tool. The simulation phase concerns the realization of the model and the various simulation scenarios. The analysis phase, concerns the analysis and comparison of simulation results.

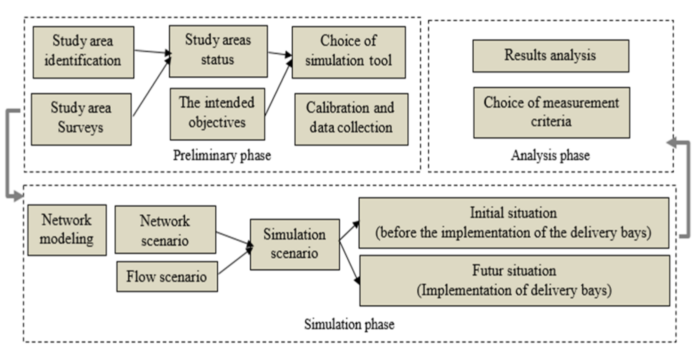

Figure 1. Delivery Areas Scenarios Simulation Approach

3.1 Preliminary phase

This step constitutes a phase of diagnosis and data collection for the preparation of the simulation model [10]. It is divided into two sub-steps:

1. Choice of simulation tools :

In this work, we are particularly interested in microscopic traffic simulation tools that offer a wealth of detail, since our goal is to study the movement and parking of each vehicle [11]. In order to facilitate the choice of the appropriate simulator, we have established a comparison of the most commonly used road traffic microscopy simulation software (TABLE 1) [12], [13], [14]. Indeed, no software is strictly better in all situations. Each has its advantages and limitations.

TABLE 1. *Synthesis of tools for microscopic simulation of road traffic*

Tools	Description
Aimsun	Software developed and marketed by Transport Simulation System (TSS). It allows to model the circulation of any type of network and to simulate different scenarios taking into account even public transport.
Dynasim	Developed by Dynalogic, it is multimodal software for modeling and microscopic simulation. It allows to model as finely as possible the flow of traffic on a network. This software integrates the functions of dynamic simulation of road, rail and river infrastructures.
Vissim	This software is developed by the German company Planung Transport Verkehr (PTV). It is a simulation tool for urban and interurban areas. It proposes a microscopic simulation of the vehicle-driver pair based on a psychological analysis of driver behavior.
Sim Traffic	It is a microscopic traffic simulation tool capable of modeling arteries with intersections and roundabouts. SimTraffic can be used to generate reports, or just for animation purposes.
Mitsim	It is a microscopic simulation tool incorporated into the MitsimLab software developed by the Massachusetts Institute of Technology. It also includes a simulator for traffic management and traffic control and road guidance systems.

We have solicited the agencies of several software to obtain an academic license: Aimsun, Vissim, SimTraffic and Dynasim. As a result, we were able to obtain an academic license "Dynasim Version 5". It is a multimodal dynamic modelling and simulation software which integrates the dynamic simulation functions of road infrastructures (Dynasim Road), rail (Dynasim Rail) and fluvial (Dynasim Fluvial). It also makes it possible to model and simulate the layout and operation of vehicles parking in urban areas [15]. It consists of a graphical editor, a simulation engine and tools for visualizing and analyzing simulation results. These three components are directly accessible from it interface [16].

2. CALIBRATION AND DATA COLLECTION

This is a step of determining and formatting the data according to the insertion parameters of the simulator in order to reconstruct the reference situation for which the operation is known [17]. Indeed, a simulation model is characterized by parameters referenced in one of the following four categories: Flows; networks; Signal and Public Transport (PT). These parameters are grouped as a scenario that generally corresponds to a hypothesis to be tested. A simulation scenario must define the network and flow scenarios, optionally the signal and PT scenarios [16].

- Flow Scenario: The flow scenario model facilitates the study of the operation of the development to be simulated during key moments of a day, as well as other future horizons.
- Network scenario: A network scenario integrates all the layers that include the simulation objects describing the paths taken by the users of the layout.

The parameters necessary for the realization of the simulation model are mainly [18]:

- The geometry of the studied areas: It is a question of defining the different trajectories of the network and the supports. Then, defining the parking situation and vehicle traffic in the studied zone.
- The characteristics of the roads: It is to specify the nature of the trajectories (monofile or multifile) and their type (fast or slow lane).
- The type and distribution of the vehicles: The parameters defining the categories are: the name; geometric quantities (Length, width); the kinematic capabilities (acceleration) and the graphical representation file of the category [19].
- The calculation of the quantity of the request associated with each category: it is based on the calculation of the matrices (Origin-Destination) of each category of vehicle.
- The regulation implemented: These data relate to the demand (number of vehicles using the network during the simulation period), the parking distribution (parking time, number of vehicles present at the start of the simulation) and the geographical position of the vehicles at the start of the simulation [20].

Once the calibration is validated, we can finally move on to the modeling of the scenarios to be studied.

3.2 Simulation phase

It is a step characterized by the realization of the model according to the input parameters of the simulator and the integration of the suggested simulation scenarios to improve the functioning of the studied system.

1. Initial situation

It is a reconstruction of the current situation of the study area before the implementation of the delivery areas. The realization of the initial simulation model is organized as follows:

- Definition of the map plan representing the geometric structure of the study area;
- Definition of a network scenario and a flow scenario;
- Definition of a simulation scenario that contains both flow and network scenarios;

2. **Future situation:** integration of urban delivery areas Between the current situation of the study area and the proposed solution, we are led to test the deployment of the delivery areas. Delivery areas are stopping and non-

Figure 2. Delivery Areas Scenarios Simulation Approach

parking spaces where a vehicle can perform these loading/ unloading operations without hindering traffic flow.

This step consists in reproducing the same model but this time by integrating the delivery areas in the elements of this model.

3.3 Analysis phase

In this step, we proceed to the visualization and the analysis of the results by using the different tools of exit present in the simulator. It is characterized by the definition and the configuration of the measuring points allowing the recovery of the results during the simulation. Indeed, the criterion represents the parameter that one wants to measure. A parameter is associated with one or more criteria. For each criterion are associated several possible treatments (average, maximum, minimum, standard deviation ...) that we can choose through the criteria configuration box.

1. Choice of measurement criteria :

The criteria chosen to demonstrate the microscopic impacts of the traffic problems that occurred in the study section, namely [5], [18]:

- Travel time: Since the first signs of congestion are mainly the slowing down of traffic, this criterion makes it possible to measure the time taken by a vehicle to cross a section of road. The variability of travel times is a useful indicator that highlights the impacts of parking practices in second place.
- Travel speed: It represents the average speed of the vehicles obtained by the quotient of the distance traveled on the journey time. The variability of the travel speed makes it possible to highlight the consequences of congestion on the flow of traffic.
- Number of stops: this criterion counts the number of stops occurring at each section of the road.
- Stop delay: It represents the time lost by a stopping vehicle.
- Inter-vehicles time: This criterion measures the time between two consecutive vehicles at a point in the network.
- Occupancy rate: This criterion is used to measure the occupancy rate of each delivery area. It is obtained by the quotient of the number of the vehicles borrowing this area on the capacity of this one.

2. Tools for visualization and analysis of results

In Dynasim, the criterion represents the parameter that we want to measure. For each criterion are associated several possible treatments (mean, maximum, minimum, standard deviation,...) that we can choose through the criteria configuration toolbox [16].

- **The animator:** This is an interactive tool that allows to reproduce, in 2D or 3D, the vehicle movements that have been calculated by the simulation engine. Through its demonstrative qualities and with the possibility of recording an animated video, it facilitates the explanation of how it works, and becomes a decision-making tool for managers who are not necessarily traffic and traffic specialists.

- **The grapher:** It allows to visualize in the form of graphs the statistical results, according to criteria measured during the simulation.
- **Tables:** They are obtained from the criteria measurements identified during the simulation. They provide a synthetic view on the functioning of the various simulated installations.

- **Flow diagrams:** These are the calculation files on flows that are obtained from the quantification of flows.

The comparison between the conditions of the initial traffic situation and the simulation results with integration of the delivery areas makes it possible to evaluate the consequences of the implementation of the delivery areas on the traffic situation in the study area.

4 CASE STUDY

4.1 Presentation of study area

Our choice was focused on the city of Fez as a case study. Therefore, we chose the Mohammed Zerktouni Street as a study zone. It is a single-store residential and commercial Street (that is, one-way traffic) that stretches for 600 m. Located in the city center, the street begins with the entrance "Atlas" and ends with an exit to Avenue Mohammed Esslaoui. We have divided this avenue into four sections. Considering the cost and the time of realization of this type of study, we decided to carry out the study on the section 1. The study zone extends over a length of 205 m from the main entrance of Mohammed Zerktouni Street to the "Patrice LEMOMBA". Indeed, this part is characterized by the existence of two inputs and two outputs. At 95 m from the main entrance, there is a two-way road (Entrance / Exit) through which the vehicles of urban freight transport transit at the Mohammed Zerktouni Street. Thus, the width of the section is about 8 m; the municipality has reserved 2m on both sides for parking. This means that it is indeed a narrow commercial street. The figure 2 presents the study area:

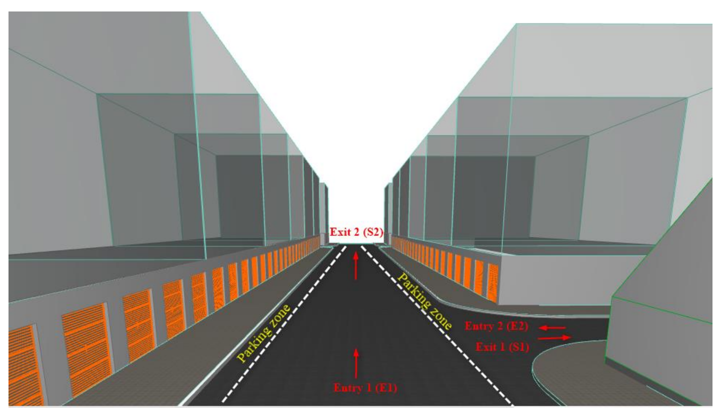

Figure 2. Study area layout

4.2 Realization of the simulation scenarios on Dynasim tool

- Step 1: (a) Definition of the layout in the form of a bitmap image representing the geometrical structure of the study section (b) Definition of the layers, i.e. the network objects (NET); the parking objects layer (DISTRI) and the results layer (RES). (Figure 3)
  - **Figure 3.** Definition of layout form and layers

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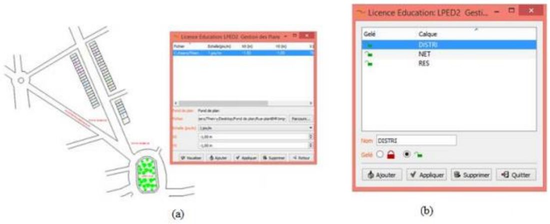


Figure 3. Definition of layout form and layers

- Step 2: Definition of a network scenario that includes three layers.
- Step 3: Elaboration of the components of the theoretical network (supports; trajectories; parking area, generators; exits; links). In Figure 4, the modeling of the study zone in logical editing mode.

- Step 4: Definition of a flow scenario entitled "PARKING" of the generator type carried out during the morning rush hour (hpm) for one hour of simulation. Subsequently, the configuration of the scenario according to the vehicle categories and the traffic quantities (Origin/Destination matrix) assigned to each category (Figure 5).

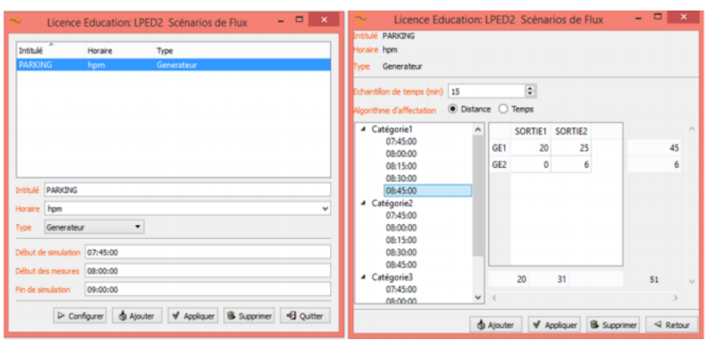


Figure 5. Definition and configuration of the flow scenario

- Step 5: Definition of a simulation scenario that contains the flow scenario "PARKING" and the network scenario "BASE". Then, Start the simulation tool by clicking on the «Replicate " button. A first simulation carried out between 8:00 and 9:00 am. Thereafter, the generation of results is obtained over the whole day from 8:00 am to 6:00 pm.

4.3 Future situation: integration of delivery areas
At this point, we have integrated the delivery area object. It is a shortly stopping a vehicle to carry out an operation (delivery/pick-up). This stop is characterized (Figure 6) by the location of its stop line positioned on the trajectory, its time, the conditions specifying which vehicles stop at this location and a time grid.

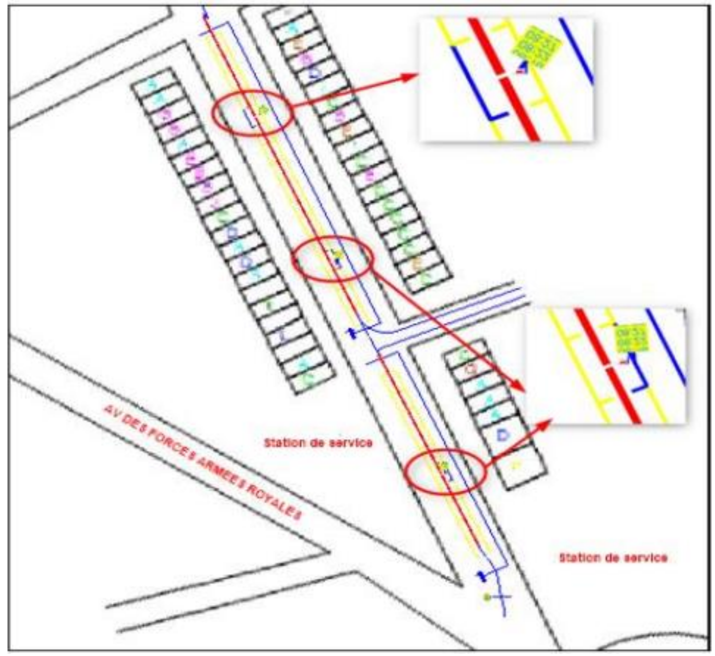


Figure 6. The study section model with integration of the delivery areas

5 RESULTS & DISCUSSIONS

4.1 Initial situation
The microscopic simulation tool "Dynasim" allowed us to model the traffic flow in the study section. The data correspond to that of a Saturday when counts on the network were considered significant compared to the rest of the week. We selected three measurement periods (morning, off-peak and afternoon). During the simulation, the animator reproduces the traffic situation and all the problems that have arisen. Indeed, as it is a narrow one-way street, congestion phenomena can be reproduced in three situations: (a) double parking, (b) the exit or entry of a vehicle in a parking situation and (c) the existence of heavy goods vehicles. These phenomena are characterized by the formation of a queue of vehicles waiting locally for a certain period (Figure 7).

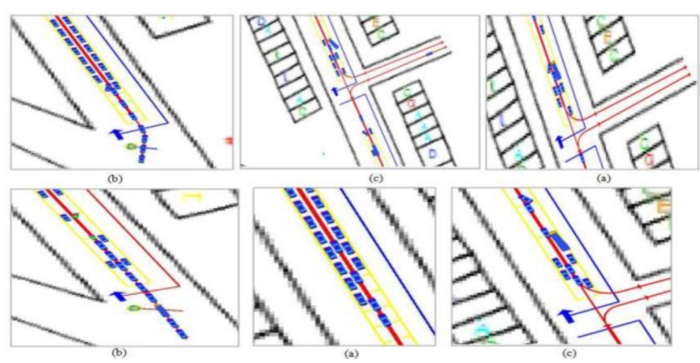


Figure 7. Vehicle traffic situation in the study section

4.2 Simulation result after location of delivery areas
After the location of the delivery areas, Dynasim simulates the traffic flow situation. The results of the study were used to

compare the road network in the studied zone with the initial situation. The Figure 8 visualizes the simulation results in the morning.

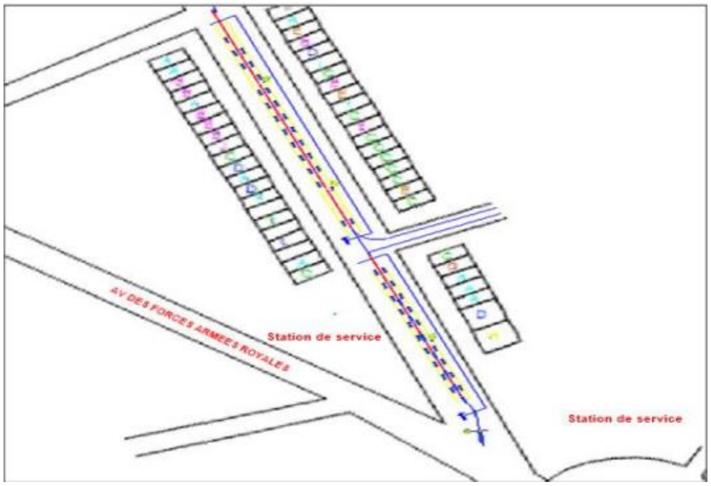


Figure 8. Simulation of traffic flow in the presence of delivery areas

By comparing the results with those in Figure 7, this image also shows the influence of delivery areas on the traffic flow.

4.3 Measurement criteria results

A set of criteria was selected to demonstrate the microscopic impacts of traffic problems in the study section.

- Travel time

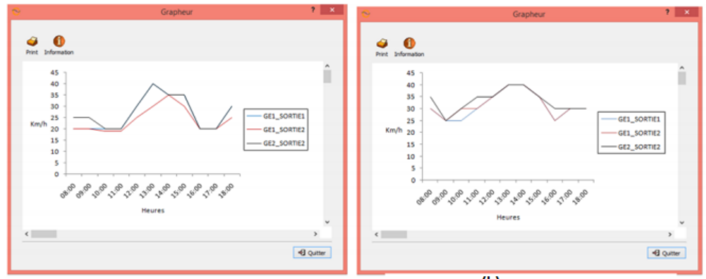
Between the current configuration of the study section (a) and the suggested configuration (b), the results of the microsimulation showed that the average travel time of vehicles using the studied network decreased compared to the initial state (Figure 9).

(a) (b)

Figure 9. Average travel time before and after location of delivery areas

- **Travel speed**

The comparison of the average travel speed of a vehicle between the two graphs (a) and (b), which correspond to the two simulation scenarios, is very significant (Figure 10). Analyzing the two scenarios, we have a strong peak between 12:00 am and 2:00 pm, which corresponds to the situation where the roadway is less dense. Indeed, before the implementation of the delivery, the roadway is densely occupied throughout the morning. As a result, the travel speed do not exceed 20 km/h. The same phenomenon occurs during the afternoon. However, after location of the delivery areas, the street is more accessible and the travel speed has increased to 35 km/hour. This shows the role of these areas in improving traffic conditions.



(a) (b)

Figure 10. Average travel speed before and after location of delivery areas

- **Inter-vehicles time**

The variability of this criterion provides an indication of the deterioration of road traffic flow [18]. Indeed, when traffic fluidity is deteriorated (a), vehicles that cross the roadway at a minimum safe distance and therefore the time between vehicles is minimal. However, in a situation where there is less traffic (b), the existing spaces between the vehicles are larger and of course, the time between vehicles increases. The results of these situations are presented in Figure 11.

(a) (b)

Figure 11. Inter- vehicles time before and after location of delivery areas

The comparison between the results of the criteria measured in the two situations approves the role of delivery areas in improving the traffic flow through reducing travel time, increasing travel speed and inter-vehicle time. These elements allow, among other things, the reduction of congestion, of road insecurity and increased accessibility.

6 CONCLUSION

In this article, we proposed a "DASSIA" approach to evaluate the impact of the implementation of delivery areas on the traffic flow using the micro-simulation. We have obtained an academic version of Dynasim tool. We have detailed all the steps leading up to the simulation. There are three main phases: Preliminary phase; simulation and post-simulation phase. In order to visualize and analyze the simulation results, a set of criteria was chosen to demonstrate the microscopic traffic problems that occurred in the study section, namely: travel time, travel speed and inter-vehicle time. Comparison of the simulation results of the reference situation and the one with delivery areas proves the role of these spaces in improving traffic flow conditions in urban areas.

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