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DynaLOAD: a simulation framework for planning, managing and controlling urban delivery bays

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Abstract

The paper proposes a simulation framework for planning, managing and controlling urban delivery schemes taking into account the real-time occupancy of delivery bays and the possibility to drive transport operators in their delivery tours providing personal and real-time information. A methodology that allows the real-time management of urban delivery operations (including prior booking) to be simulated and the performance indicators (to be used in the *ex-ante* assessment of delivery scenarios) to be computed was developed, on top of an application for testing the presented methods and for pointing out the importance of using telematics applications for managing and controlling such operations. Significant results were obtained according to some management and operations control rules.

Keywords: Type your keywords here, separated by semicolons ;

1. Introduction

Commercial vehicle traffic in inner city areas is a matter of concern for city authorities for several reasons (Russo and Comi, 2016a). Freight vehicles contribute to congestion especially in peak hours. This aspect is of particular interest wherever local conditions oblige freight vehicles to stop for loading and unloading outside designated spaces.

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Vehicles can stop at junctions or along a lane, in both cases leading to a reduction in capacity, and the problem is more serious for medium or heavy goods vehicles (Bouhana et al., 2015). Reversing the perspective, there is a problem of meeting the needs of truck drivers, which are delayed by traffic and have difficulties in accomplishing their loading and unloading (delivery) tasks, especially because of insufficient parking spaces. Some surveys with transport and logistics operators highlighted that the non-availability of such areas is one of the main issues of urban freight distribution (CERTU, 2009; Rinnan, 2008; De Oliveira, 2014; Nuzzolo et al., 2016). Therefore, some cities are planning to increase the number of on-street delivery bays, which are spaces dedicated to freight delivery operations in order to reduce the impact of goods movement and to meet operator needs (Ducret et al., 2016). On the other hand, the lack of urban space makes it desirable to find also other solutions for delivery vehicle parking and defining regulations that can be used to reorganize parking spaces. For example, in some districts of Paris, all new commercial and industrial buildings have to provide off-street delivery bays for reducing the influence of commercial transport (Patier, 2006; Chatterjee et al., 2008; Cherretta et al, 2012).

Today, the on-street delivery bay schemes can be nested in three main classes: *on-street* delivery bays, i.e. the allocation of curb-side parking spaces to serve as delivery area with some specific rules (e.g. time limits or load factors); *bookable on-street* bays, e.g. in Imola (Italy), where reservation is performed through web or phone (Ferrecchi, 2013); on-street delivery bays equipped with *intelligent transport system* (ITS), including advanced management and operations control systems, currently in development (Zuccotti et al., 2011; Marciani and Cossu, 2011; McLeod and Cherrett, 2011; Patier et al., 2014; Nuzzolo et al., 2015).

A review of these solutions along with their results has been carried out within some European projects (Straightsol, 2014; Patier et al., 2014; Ducret et al., 2016). One of the findings of these research projects was that the problem has not been solved yet. It is thus considered crucial to have simulation models to analyze these solutions prior to implementation in order to evaluate *ex ante* their possible impacts. In fact, especially in the city centre, the scheme of delivery bays has to be carefully planned and managed, for example, through a methodology that supports simulating real-time management of urban delivery operations (including prior booking by delivery operators) and to compute performance indicators to be used in the ex-ante scenario assessment. Nevertheless, literature seems quite limited and further investigations should be done (Muñuzuri et al., 2012; Letnik et al., 2015; Gardrat and Serouge, 2016). In particular, Aiura and Taniguchi (2005), Dezi et al. (2010) and Delaître and Routhier (2010) focused on optimal locations of on-street delivery bays, while Alho et al. (2014) defined a general framework that considers both private vehicle occupation and illegal vehicles parking.

Therefore, in this context, the paper aims to present a methodology for supporting city logistics planners and experts when planning, managing and controlling on-street delivery bay schemes. The proposed methodology allows real-time management and operations control of a given delivery bay scheme (including prior booking and optimization of delivery tours) to be simulated. The on-street delivery bays are properly located and sized according to the delivery demand, and the use of a dedicated set of management rules can maximize their performances. On the other hand, in order to optimize the delivery costs supported by operators, a prototypical tool for the management and the control of delivery bays will be set up.

The paper is organized as follows. Section 2 gives an outline of the proposed simulation framework for planning, managing and controlling delivery bay schemes, while Section 3 reports the results obtained by its application to a real test case. Finally, some conclusions and further developments of this research are drawn in Section 4.

2. DynaLOAD: the proposed simulation framework

This research is part of DynaLOAD (planning and DYNAmic management of urban LOADing and unloading areas) project, funded by University of Rome Tor Vergata through the “Uncovering Excellence” research program. The project was split in three main phases (Fig. 1): preliminary phase, planning phase, management and control phase. Preliminary phase aims to identify the critical stages of the study area according to city sustainability and livability goals. Planning phase aims to set up a methodology to support delivery scheme planning able to meet/satisfy the requirements of city planners and experts when planning and assessing such a measure (i.e. to meet the delivery demand in order to favor the legal use of road parking and the reduction of the interferences with other road users). Then, the third phase focuses on bay management and control. The main idea is to develop an advanced delivery system that permits users to book delivery bays ahead of their arrival (e.g. some days before or some hours ahead or just approaching the bay – i.e. last minute booking). Such a system provides information based on the real-time network state and constitutes an effective tool for improving the quality and effectiveness of delivery services. Indeed, transport and logistics operators are allowed to book urban delivery bays, to receive suggestions on delivery tours (according to the characteristics of deliveries to be performed, delivery constraints and proximity of delivery bays) and hence to optimize the time spent for these freight operations. Besides, recent ITS developments (e.g. Automatic Vehicle Location) and the implementation of citywide ITS platforms could supply personalized and predictive information (travel time) taking into account the real-time road network state. Finally, the system allows the different performance indicators to be computed (e.g. total service time, vehicle request, vehicle on queue and queue waiting time), to be used in monitoring and ex-post scenario assessment.

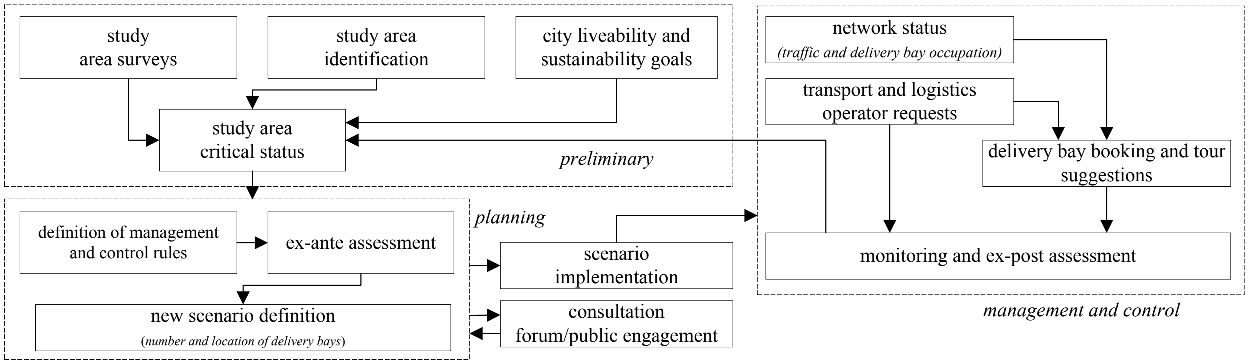

Fig.1. DynaLOAD framework

2.1. Preliminary phase

The aim of this phase is the definition of the elements founding the analysis system and of their relationships. The elements of interest pertain to three main spheres:

- the demographic, economic and spatial characters of transport demand,
- the supply of transport and logistics infrastructure and services, and
- the external environment, as it plays a role in the estimation of some impacts.

Besides, to identify and build possible delivery bay scenarios, it is important to take into account each stakeholders' point of view (Taniguchi, 2015; Marcucci et al., 2015; Russo and Comi, 2016a) focusing on the different concerns and objectives which could also require *ad-hoc* surveys (Nuzzolo et al., 2016). Referring to the choice process, the decision-makers (actors) involved in urban freight transport can be classified into:

- goods receivers: economic activity managers, as well as retailers and ho.re.ca. (hotel, restaurant and catering) ones; their choices are mainly related to restocking movements (e.g. frequency and size of delivery); their main interest is to receive good at low cost on top of having a highly attractive/livable city;
- end-consumers: inhabitants (residents or businessmen/employees) and visitors/shopping users; their choices are related to end-consumer movements primarily through the journeys for purchasing; their main interest is minimizing hindrance caused by goods transport and having a variety of products in shops at a low price, or a high quality/price ratio;
- transport and logistics operators: shippers (wholesalers), transport companies, receiver/shop owners that operate restocking on own account; their main interest is minimizing hindrance caused by goods transport;
- public administration: local/national government and administrative institutions; their aim might be to organize an attractive city for inhabitants and visitors, with minimum hindrance, through effective and efficient transport operations.

Despite all stakeholders desire the minimum hindrance, it is essential that public administrations establish the efficient number of delivery bays. Indeed, although a higher number of bays would increase the probability for transport and logistic operators to find parking close to destinations, too many delivery bays can cause the decrease of public spaces and car parking. Besides, delivery planning should allow public administrations not only to design the appropriate configuration of bays in a target zone, but to address stakeholders' requirements too (Russo and Comi, 2016a and b).

2.2. Planning phase

DynaLoad planning framework implements the methodology pictured in Fig. 2 in order to provide in output the optimal number and location of delivery bays in the study area. It consists of the following stages:

- scheme and *study area* definition and zoning (1), i.e. this phase delineates the geographical area that includes the transportation system in analysis and encompasses most of the scenario effects; according to delivery requirements, the set of traffic analysis zones is also identified;
- estimation of *temporal delivery demand* (2), i.e. number of delivery operations attracted by each traffic zone of the study area in a given day time period, using a freight survey and/or demand modelling systems;
- estimation of *distribution* values of freight *vehicle arrivals* and of *delivery operation times* (3) according to the forecasted demand and type of goods;
- *scenario definition* of delivery area systems (4), i.e. according to the demand characteristics and urban road network, delivery bays are spatially distributed within the traffic zone with respect to some general rules (e.g. walking distance to shops to be delivered);
- *management simulation* of delivery area system scenario (4), i.e. considering a given configuration of delivery bays, the simulation of the use of each delivery bays is performed according to the characteristics of delivery operations and some management rules of the global delivery area system, with the objective to optimize the delivery operations and the delivery tours;
- evaluation of *performances* (5), i.e. the output of simulation provides the input for this evaluation stage; indeed, some indicators (both for operators and administrators) can be computed and compared with targets or benchmarks in order to verify if the new scenario improves the delivery operations.

Scheme, study area definition and zoning. According to the aim of the study, the geographical area that includes the transportation system (facilities and services) in analysis has to be identified. In this phase, the existing delivery bays and the current traffic regulations have to be investigated. Besides, to spatially characterize the delivery demand, it is necessary to subdivide the study area into a number of discrete geographic units called "traffic analysis zones". Zoning can have different levels of detail. For example, traffic zones may consist of one or a few blocks with respect to delivery point locations (e.g. shops).

Estimation of temporal delivery demand. The knowledge of demand in terms of delivery bays and users' behavior in an essential step of the planning methodology. Detailed information regarding requested delivery can be, for example, obtained through surveys. Surveys should allow data from freight and non-freight mobility to be gathered. In particular, freight data could consist of traffic counts, interviews with freight receivers (e.g. retailers) and with truck drivers. Furthermore, it should provide data to a demand modelling system, aiming at predicting changes in delivery requirements under future scenario assumptions. The demand modelling system should allow us to capture the effects of such city logistics measure on actors' behavior and provides as output the Origin-Destination flows in terms of deliveries, disaggregated for freight types (s) and time of the day (h). Among the others (Comi et al., 2014), a demand modelling system that gathers the main requirements for such analysis consist of three main steps (Comi and Nuzzolo, 2016):

- *shopping model sub-system*; it allows to simulate end-consumer shopping behavior, estimating the quantities bought at store and the number of e-purchases; therefore, the goods flows attracted by each traffic zone can be identified;
- *shop restocking model sub-system*; given the quantity attracted by the shops in each traffic zone, it allows us to estimate the restocking origin-destination (O-D) matrices by goods type and type of used vehicle;
- e-*purchase delivering model sub-system*; given the number of online purchases by end consumers living in each traffic zone, it allows to estimate the e-purchase delivering O-D matrices by goods type and vehicle used.

In particular, the restocking and e-purchase delivering model sub-systems provide the following outputs:

- the average quantity O-D matrices characterized by freight types and transport service type *r* (e.g. retailers or wholesalers performing transportation on own account or using third-party carriers);
- the average delivery O-D matrices by delivery time period *h*, i.e. the quantities computed in the previous point are converted into delivery O-D flows;
- the average vehicle O-D matrices by delivery tour departure time (*t*) and vehicle type (*v*); it allows to obtain the vehicle O-D flows satisfying the given delivery O-D matrices, investigating the tours undertaken to restock the study area; in particular, the tours are characterized by departure time, number of stops, vehicle used and sequence of delivery locations.

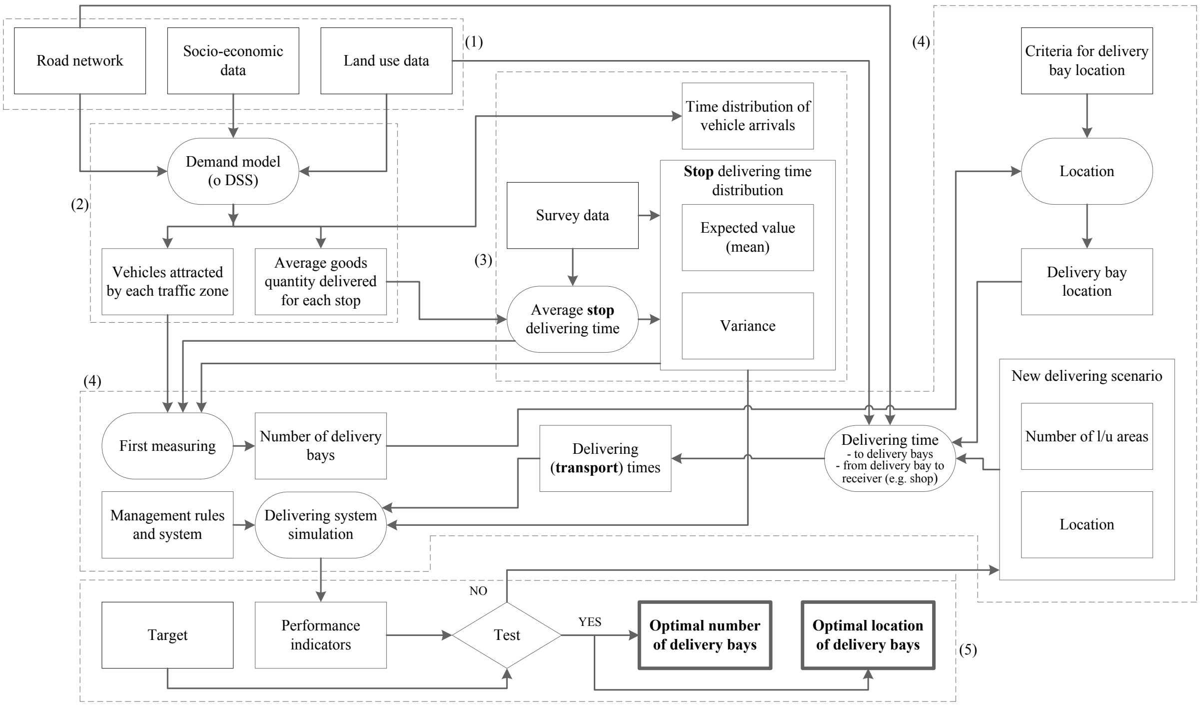

Fig. 2. Methodology for planning delivery bays in urban area

For the sake of readability, the modelling framework has been briefly recalled. For more details on modelling specification, refer to Comi and Nuzzolo (2016).

The estimation delivery operation time. Once, the Origin-Destination flows in terms of deliveries are estimated, the next stage focuses on modelling freight vehicle arrivals and delivery operation times (delivery time distribution, i.e. average and variance values), according to the characteristics of delivery demand identified above. The time, $T[v,r,s,h]$, requested for performing delivery operations, depends on the time of day *h*, type of freight *s* to be delivered, type of the service *r* and type of vehicle *v* used. It can be assumed to be a random variable:

$$T[v,r,s,h] = t[v,r,s,h] + \varepsilon[v,r,s,h] \tag{1}$$

where $t[v,r,s,h]$ is the mean of delivery time $T[v,r,s,h]$, i.e. $E[T] = t$, and ε is the random term with $E[\varepsilon] = 0$. Let be $\sigma\,[v,r,s,h]$ the standard deviation of the delivery time T: $\sigma[v,r,s,h] = \sqrt{\mathrm{var}[T]} = \sqrt{\mathrm{var}[\varepsilon]}$.

According to the data revealed in the urban areas, different on-street delivery time distributions can be estimated in order to obtain the time requested for performing such operations.

The scenario definition. Given the number of delivery operations that can occur in a given time period *h* and the time requested for performing each operation *T*, an initial estimation of the number of delivery bays can be obtained and, hence, the relative delivery bays scenario can be *simulated* according to some *management rules* of the delivery bay system. In particular, each delivery area is assumed to host one freight vehicle at time, being the type of vehicle *v*, the type of service performed *r* and the type of freight *s* known. The definition of optimal spatial location of delivery bays among different feasible scenarios according to some base constraints (e.g. walking distance to shop to be restocked) can be also provided, by simulating the main effects of exogenously specified delivery schemes, verifying their technical compatibility and evaluating their "convenience" as "what if" approach. By contrast, "what to" indications can be provided using optimization models. In particular, the definition of optimal delivery scenario could be performed exploring various methods developed for solving facility location problems (Munuzuri et al., 2012; Alho et al., 2014), and the identification of the functional rules to manage delivery bays, e.g. through an analysis of the possible system states. Despite the presence of a booking system - which allows users to reserve a bay in a specific time slice - delays or arrivals early can occur due to stochasticity of the road network. In these cases, the system has to determine the access priority rules in order to allow user to perform deliveries. In the analysis of the system states, it is crucial to consider that the delivery bays could be occupied by cars or by vehicles not using the system. Thus, an enforcement structure implemented before the introduction of the management system is supposed to be present, so these events probability - on top of illegal occupation – tends to zero.

Evaluation of performances (scenario assessment). The delivery scenario can be modelled through discrete-event simulation, as proposed in Section 3, based on the rules and assumptions described before. A list of goods vehicles requesting to use the delivery areas within the study area can be, at a first instance, assumed to follow a Poisson distribution. Once, the scenario is simulated, some performance indicators have to be estimated and compared with some target or benchmark values in order to identify the improvement that can be obtained by scenario implementation. According to the city planner's point of view, the assessment methodology is able to evaluate ameliorative scenarios in terms of transportation costs, and different indicators can be used as proposed by Melo (2010) and Nuzzolo et al. (2015). Examples of indicators strictly related to delivery scheme are: average delivery request, total and average loading – unloading (delivery) time, number of delayed delivery vehicles.

2.3. Management and control phase

The aims of the system are to guarantee delivery bays availability and to discourage undesirable drivers' behaviors (e.g. doubleparking). Once that drivers ask to book a delivery bay, they have to provide information regarding the whole delivery tour (i.e. number and location of deliveries, types of goods delivered at each stop, time constraints, tour time departure). The delivery system, among the available delivery spaces, identifies the best set of delivery bays that allows the total operations lead time to be optimized. The users can also indicate an initial preferred delivery tour. Then, if all delivery bays are available, these will be booked with respect to the time forecasted for performing the defined deliveries. On the other hand, changes to delivery order can be suggested. Users can validate or not the suggested change and eventually return to the system so that the actual tour is pointed out.

The control system involves a set of rules for dealing with the incoming practice situations. The vehicles are detected on the proximity of the city areas (i.e. they are equipped with a bi-directional communication system). The vehicles are checked to determine whether they are on time, early or late for their booking. This requires to forecast the times needed to reach the first and the following booked delivery bays. The vehicles arriving early for their booking could immediately access the bay if it is available or they could be asked to wait in a defined area until the bay is available; else, to update the sequence of delivery bays to be reached. The vehicles arriving late are allowed to use the remaining time left on their booking schedule (subject to a minimum use requirement) or to extend their booking schedule if time slots are available. Otherwise, an alternative delivery tour is suggested.

Anyway, many different types of booking system can be supported (also more simple versions with respect to the above presented) according to specific requirements.

3. Application to a real test case

The proposed simulation framework was applied to the Campo Marzio district (study area) in the inner area of Rome, in order to verify the goodness of the approach and to evaluate the benefits on the usage of an advanced management and control system, which gives suggestions on which delivery bays to be used and allows the suggested delivery bays to be booked when the study area is approached. As previously detailed in Section 2, different management rules can be supported and, in the following test, it is assumed that:

- a strong enforcement system is implemented; no delivery operations outside dedicated bays are performed;
- freight vehicles are generated based on queuing, with respect to the data collected in the study area (for more details on survey data refer to Nuzzolo and Comi, 2015);
- the delivery bay can only be booked when the study area is approached; the driver is asked to provide some information regarding his/her delivery tour (i.e. location of delivery point, type and quantity of freight to be delivered, type of vehicle used).

The test refers to a working day from 6 am to noon. In Campo Marzio, an electronic system of access control exists for both passenger and freight vehicles. The district has an extension of 2.5 km^2 and 23 on-street delivery bays are present. According to the retail characteristics and to transportation system, 81 traffic zones were identified as possible destinations of freight vehicles approaching the study area for goods deliveries.

Following the proposed methodology, the demand in terms of deliveries and vehicles was estimated (Comi and Nuzzolo, 2016) and the time arrival distributions were also identified. There are 210 vehicles that request to deliver within the study area with a peak between the 9.00 and 9.30 am. 75% of them are light goods vehicle (i.e. gross laden weight less than 1.5 tons) and the remaining 25% are medium goods vehicles (i.e. less than 3.5 tons). With respect to type of transport service *r*, 45% are "wholesaler on own account", 15% "retailer on own account" – i.e. meaning they perform the transportation operations on their own – and the remaining 40% "by carrier" – meaning they exploit a third-party carrier. When a vehicle makes a request, the system selects the optimal delivery bay, among the available ones, comparing the time for parking and delivering goods. The distance between the selected delivery bay and the delivery point (e.g. shop) must not exceed 15 minutes.

Besides, with respect to the characteristics of delivery, the system estimates the time needed to perform such operation using the eq. *(1)* whose calibrated models are reported in Table 1. The model provides the estimation of average delivery time *T*, according to six identified freight types: building, clothing, foodstuffs, home accessories, hygiene and personal products, stationery, other goods types. The average delivery time *t* has been assumed a linear combination in the coefficient β of attributes related to: quantity of freight to be delivered (q); type of vehicle used (v), type of transport service (r), type of sender (i.e. wholesaler) or receiver (i.e. hotel, restaurant, catering – ho.re.ca.). The average estimated delivery time for one vehicles is about 19 minutes with maximum value about 42 minutes for medium goods vehicles delivering building material and a minimum value about 12 minutes for light goods vehicles delivering hygiene and personal products. The total service time for the use of each delivery bay has been calculated considering also the transfer walk time from delivery bay to delivery point, evaluated using a walk speed of 0.65 m/s when goods is transported and 0.95 m/s for empty return trip.

Using the above described data, two scenarios were simulated: an *action scenario*, that includes an ITS system providing last minute booking according the real-time status of the delivery system; a *base scenario*, that is a scenario in which no booking service is supplied. In the latter scenario, delivering vehicles choose the closest delivery bay to their destination (i.e. delivery point) regardless of its status or the presence of queues; when no parking space is available, they wait. It has to be noted that if the enforcement level is not adequate, drivers could be pushed to illegally park and perform operations out of delivery spaces. The evaluation of the ITS benefits introduced in the "action scenario" have been computed using, as performance indicators, *total service time*, *vehicle request* for using delivery bay, *vehicle on queue* at each delivery bay, *queue waiting time*.

The results of the simulations ran for the two proposed scenario, summarized in Table 2 through the above mentioned indicators are impressive: the usage of the ITS system reduces the total delivery time by about 66%. The *vehicles request* for a specific delivery area decreases by about 65%, indicating a better distribution vehicles arrivals over the available delivery bays. The decreasing in the request of a single area causes the reduction of queues also, where maximum value decreases from 36 vehicles to 5 vehicles with a reduction by about 86%; it is also possible to observe a reduction by about 3% on the average queue length. This kind of effect is greater considering the delay times of vehicles in queue (-9%). The reduction observed on the maximum delay value is about 88%. However, all indicators suggest an important decrease of the standard deviation which definitely indicates a better distribution of the vehicle demand over the delivery bays of the district and, hence, a better usage of the parking resources managed by ITS system.

Table 1. Estimated parameter for average delivery time (in minutes)

goods types		constant	quantity	light goods vehicles	retailer on own account	by carrier	wholesaler	ho.re.ca.	R^2
			kg	*0/1*	*0/1*	*0/1*	*0/1*	*0/1*	
building	β	24.15	0.01	-10.90	3.23	11.35	5.13	-7.33	
	t-st value	*1.79*	*1.44*	*-1.43*	*2.38*	*2.14*	*1.59*	*-1.63*	**0.28**
clothing	β	8.71	0.01	0.75	0.47	4.57	-3.39	-4.13	
	t-st value	*1.67*	*2.57*	*1.26*	*2.13*	*2.78*	*-1.95*	*-2.03*	**0.21**
foodstuffs	β	8.86	0.02	0.35	2.17	0.65	3.43	-4.10	
	t-st value	*2.12*	*3.73*	*1.16*	*1.70*	*1.26*	*1.43*	*-1.76*	**0.29**
home accessories	β	19.84	0.01	-12.32	5.90	5.86	11.37	-11.6	
	t-st value	*3.51*	*2.15*	*-3.36*	*1.61*	*2.53*	*2.58*	*-2.72*	**0.48**
hygiene and personal products	β	16.16	0.03	4.45	5.75	-4.82	-3.28	16.16	
	t-st value	*1.72*	*3.19*	*1.72*	*1.49*	*-2.00*	*-1.63*	*1.72*	**0.45**
stationery	β	20.17	0.01	-1.74	13.61	13.40	-5.35	-8.95	
	t-st value	*3.63*	*1.42*	*-1.53*	*3.27*	*4.34*	*-1.66*	*-2.98*	**0.36**
other goods types	β	14.68	0.03	5.67		-4.25			
	t-st value	*3.41*	*3.28*	*3.28*		*-1.77*			**0.20**

Table 2. Comparison between simulated scenarios: action *vs* base scenario

	vehicle request			**vehicle on queue**			**queue waiting time [min]**			**Total service time [min]**
Scenario	*max*	*avg*	*st. dev*	*max*	*avg*	*st. dev*	*max*	*avg*	*st. dev*	
action	16.0	10.5	3.2	5.0	00.9	0.50	51.5	32.6	14.1	**413.0**
base	46.0	10.5	9.1	36.0	0.94	3.43	430.5	35.8	91.8	**1204.0**
% differences										
Δ	**-65%**	**0%**	**-65%**	**-86%**	**-3%**	**-84%**	**-88%**	**-9%**	**-85%**	**-66%**

The logical architecture of the proposed tool

Once the benefits of using a delivery bays management and control system have been highlighted, the design of a telematics tools for supporting real time transport operators was investigated.

The first step in the definition of its framework (ARTIST, 2003) was the definition of the user needs that the tool has to satisfy and which characteristics must be pointed out in planning phase:

- delivery path alternative enumeration, according to some transport and logistics preferences (e.g. maximum distance between on-street delivery bays and delivery point – e.g. shops);
- information on real condition of the transport system operations for each path (departure time, walking times and distances, delivery bays state, travel times among the different delivery points, congestion, and so on).

According to the above user needs, a logical architecture of the component of the tool, currently in a development phase, has been implemented to support transport operators with personalized pre-trip information.

Relating to the specific zone, the tool considers the road network and time/city delivering constraints and real-time data on vehicles location, traffic and delivery bay availability. A pre-trip personalized advisor module is enabled by a query of user *i*, who is logged into the system. In particular, at time τ in which user *i* asks for a support to travel from origin to delivery point (e.g. shops), the system identifies and ranks the delivery tours choice set of user *i*, based on his/her preferences and the current information on the road network (i.e. travel time forecasts and AVL real-time data). In order to provide to the user *i* a ranking of alternative delivery tours, in the framework of the Random Utility Theory (Ben-Akiva and Lerman, 1985), personal utility parameters β_i of user *i* are used to calculate delivery tour utility for all delivery tour belonging to the delivery tour choice set of user *i*. The delivery tour chosen by user *i* is added to the personal database of revealed preferences of user *i*, which updates the personal parameters β_i by using an user preference learning procedure, similar that proposed by Nuzzolo and Comi (2016) for transit travellers. The information on delivery tour choice of the user *i* represents the main input of the en-route path information module, aiming at supporting user *i* during the delivery tour and to be developed in the next step of the research.

Based on this logical architecture, a prototype has been developed. The prototype is composed by two main parts. The main component is a web application that manages communication between the database and the communication responsible with Google API in order to solve routing related issues. The second component is a mobile app that can support transport and logistic operators in managing their delivering, pre-trip and en-route. It was developed in Android and is able to show and update real-time routing, considering user location and traffic congestion. Some extensions are in progress in order to improve vehicle routing by pointing out the potentiality offered by real-time data (Adamski, 2011).

4. Conclusions

The paper proposed a methodology for supporting planning, managing and controlling the delivery schemes within urban areas and presented a scenario analysis using a discrete event simulation approach. In addition, the logical architecture of tool for supporting transport and logistics operators delivering in urban area is also described. The proposed planning methodology copes with randomness of vehicle arrival and delivery times. In a real test case, a future scenario was simulated and its performances were compared with a base one. Future delivery scheme shows that vehicles approaching the study area (i.e. a district in the inner area of Rome) can effectively benefit of suggestions on which delivery bay should be used according to characteristics of their trip and to book it in advance in order to perform delivery operations. Preliminary results confirm the goodness of the proposed methodology framework and, at the same time, demonstrate that in those areas where little space is available for such operations, the ameliorative margins of delivery bay management and control can be significant. The second stage of the research will be addressed to improve the models and to overcome the exemplificative assumptions introduced in the planning phase, for example simulating a new delivery scheme that permits prior booking, and to have suggestions on delivery tours. According to management and control phase, the future research will be addressed to investigate the calibration of individual tour utility models and the learning process, and to test the tool providing real time suggestions to transport and logistics operators. Such tools can represent an effective support both to transport and logistics operators, and city administrators as well. Transport and logistics operators can thus further reduce the time spent for freight operations as well as their delivery costs. From the city administrator point of view, this research can help in right-sizing the delivery bays and, hence, reducing the interferences with other city mobility components, in order to improve city sustainability and liveability.

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