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Urban freight transport in Bologna: Planning commercial vehicle loading/unloading zones

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Abstract

Many European and overseas studies have brought into focus issues related to urban freight transport in order to find possible solutions (city logistics). Urban areas, instead of being living, commercial and resting places may have their functions jeopardized either due to the intense and short range road good's transport and by the lack of infrastructure. Commercial vehicles are detrimental for the urban environment, polluting with gasses and noise. The "just in time" policy of no warehousing enhances this kind of transportation. This paper describes some technical solutions for the management of stop and access areas for goods transport vehicles in order to allow the on-time delivery as well as to mitigate the traffic induced issues towards citizens.
In particular, we focus attention on various issues concerning the areas where goods are loaded and unloaded, proposing a method that allows their size, their number and their location to be optimised.

Keywords: City logistics; urban mobility; freight transport

1. Introduction

In Europe more than 75% of the population lives in the city agglomerates where the flow of goods and services are localized and centrally generated. A total of 20% of the city's productivity is credited to this industry (HGV > 3.5 t) and that amount is higher if you consider vans with a mass below 3.5 t, as well as cars that are increasingly used to sort goods. Therefore, in order to protect the collective interests, public administrations are called on to adopt measures capable of reconciling two conflicting goals among which there is a potential trade-off (situation in which a gain compared to a given objective necessarily implies a loss in regards to another). On one hand the need for ensuring an efficient distribution of goods and capability of responding to requests from retailers that carry the just in time policy, the other the desire to place restrictions on freight traffic to minimise the environmental impact (Maggi, 2001). City logistics identifies solutions to regulate access, circulation and the parking of commercial vehicles in urban centres, implement policies without restrictions that are harmful to economic and social prosperity of themselves and conducive to relocation of economic activities and population (Schaffeler and Wichser, 2003).

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Also for Bologna, a city with historical origins of urbanisation, the transportation of goods represents a primary element of importance. The purpose of this paper is to improve, through an experiment conducted with a series of on-site surveys and subsequent studies, the situation of the city of Bologna and to propose solutions able to develop the urban transport of goods for the area mentioned above.

2. Freight Transport in Bologna

2.1. MerciBo2

Bologna has a tool for distribution and collection of goods in the urban area called MerciBo2. With this plan, approved in March 2006, the Municipality of Bologna will encourage the process of reorganization of the logistics and urban distribution of goods, in order to reduce kilometres travelled by vehicles, including the use of less polluting vehicles. The plan contains innovative aspects concerning the management of access to the limited traffic zone (LTZ) and others related to the proper use of parking spaces through optimisation of the areas for loading/unloading goods (Urban Mobility Municipality of Bologna, 2005). The reorganization of the distribution of goods will reduce the high number of ownership deliveries occupying public spaces already deficient, compared with a modest contribution to the distribution of goods. The most significant data related on the level of saturation of the vehicles are:

- 67% of vehicles entering the LTZ use less than 25% of their capacity;
- 12% of vehicles entering the LTZ use less than 50% of their capacity;

There are margins for improvement in distribution in the LTZ to be found by better use of parking spaces, a higher degree of utilisation of vehicles load capacity and the transfer of market share from owner based transport to third parties.

2.2. Freight transport in LTZ: relevant data and previous investigations

The survey conducted by the Municipality of Bologna focused only on the categories of vehicles for freight transport (vans < 3.5 t < box trucks < 7.5 t < trucks). To quantify the number of commercial vehicles that enter the historic district daily, it was referred to the campaign of 2004 counts performed on 9 gates that permit vehicles entering the LTZ during the business days of the winter period. The analysis covered an all day interval in which they forced the access limitations (07.00 - 20.00). There are approximately 1,900 commercial vehicles that enter the LTZ daily, of which 841 have ownership, and 941 are third party deliveries, for a total of 29,300 deliveries. For each delivery there are 0.17 corresponding pick-ups.

With the same number of vehicles, the deliveries carried out by third parties (15,000 stops: 12,600 deliveries and 2,500 pick-ups) are almost twice than the number of deliveries carried out by owner transporters (8,800 operations: 7,700 deliveries and 1,100 pick-ups). This data shows that the owner based transport is less organized and efficient compared to others who may rely on tested and telematic systems for sorting and controlling goods throughout the distribution process (Department of Mobility and Transport Emilia-Romagna Region, 2005). The “MerciBo2” plan confirms that to satisfy the demand of the loading and unloading generated from regular distribution activities, it would be necessary to have at least 1,100 MCVLZ (Multiple Commercial Vehicle Loading and Unloading Zones) rather than the 500 currently available.

Analyzing in detail some of the data on the loading/unloading showed that every delivery takes about 14 minutes for loading/unloading and that 27% of pick-ups per day (5,700), are carried out in the area called "T" (prohibited area for almost all vehicles formed by the streets Indipendenza - Rizzoli - U. Bassi) represented in gray in Figure 3. Figure 1 also contains data relating to the causes of non-use of the SCVLZs (Single Commercial Vehicle Loading/Unloading Zone) and practices of stopping found for commercial vehicles within the LTZ.

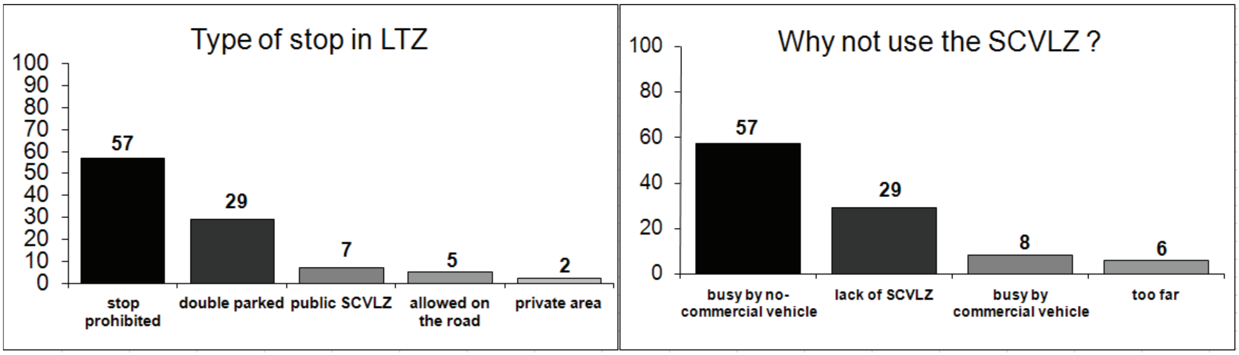


Figure 1 Type and reason of not using the SCVLZ

3. Optimization of the Logistic Scenario

In light of the above, the University of Bologna has recently conducted an investigation to finalize the methodology of analysis and a functional loading and unloading plan of the goods, in a mid-sized city, like Bologna. The study has several phases, starting with the quantification and location of parking spaces in the historic district and the characterization in terms of employment, through a detailed analysis of the areas served in relation to the time of stopping. This led to the definition of criteria of optimisation in the process of location and use of the spaces themselves.

3.1. Data acquisition and on-site investigation

The study of the existing logistic scenario in Bologna cannot be separated from the acquisition of information, data and graphic tools with which to analyze the state of affairs in terms of access of commercial vehicles to the city centre and the number, location and use of parking spaces.

In general, the information to be acquired is large and, sometimes, the availability is linked to the existence of specific plans and programming tools that are released. The Municipality of Bologna is to this effect linked with a Geographic Information System called CityTrekWeb, a type of thematic map of the municipality on-line where the parking areas are reported together with road directions and addresses of both residential and commercial buildings. The SCVLZ employment was assessed for a period of 30 minutes, from 10.30am to 11.00am, during business days in the month of March 2008, on the basis of the freight transport data relative to the access vehicles at the 9 telematic gates that permit vehicles entering the LTZ. It studied the time and the number of operations of the loading and unloading (l/u). To complete the study some researchers had unanimously verified and photographed the location and the dimensions of the MCVLZ, where they worked, the presence and position of their vertical and horizontal traffic signs, the adjacency of the SCVLZ to form a MCVLZ and their localization inside the LTZ. The data collected were rearranged in tabular form and returned on the same plan in order to facilitate the next phase of the analysis. Table 1 and Figure 2 give an example of the database created.

Table 1 Extract from the database

MCVLZ	LOCATION		SCVLZ	TYPE OF	TYPE OF VERTICAL TRAFFIC SIGNS		MAINTENANCE OF TRAFFIC SIGNS		SURVEY TIME		in
n°	Street/Square	n°	n°	USE	Time	Type of permit	Vertical	Horizontal	dd/mm/yy	h.	LTZ
00001	Saragozza	71	2	Free	20'	DS	perfect	good	18/03/08	10.31	yes
00002	P.ta Saragozza	6	2	Busy ill	20'	DS	perfect	good	18/03/08	10.33	no
00003	Sant'Isaia	68	1	Busy ill	20'	DS	good	insufficient	18/03/08	10.38	yes
00004	Sant'Isaia	40	1	Busy ill	20'	DS	good	sufficient	18/03/08	10.40	yes
00005	Frassinago	3	1	Free	20'	DS	perfect	good	18/03/08	10.44	yes
....	....	...	....	....	....	....	....	....	....	....	......

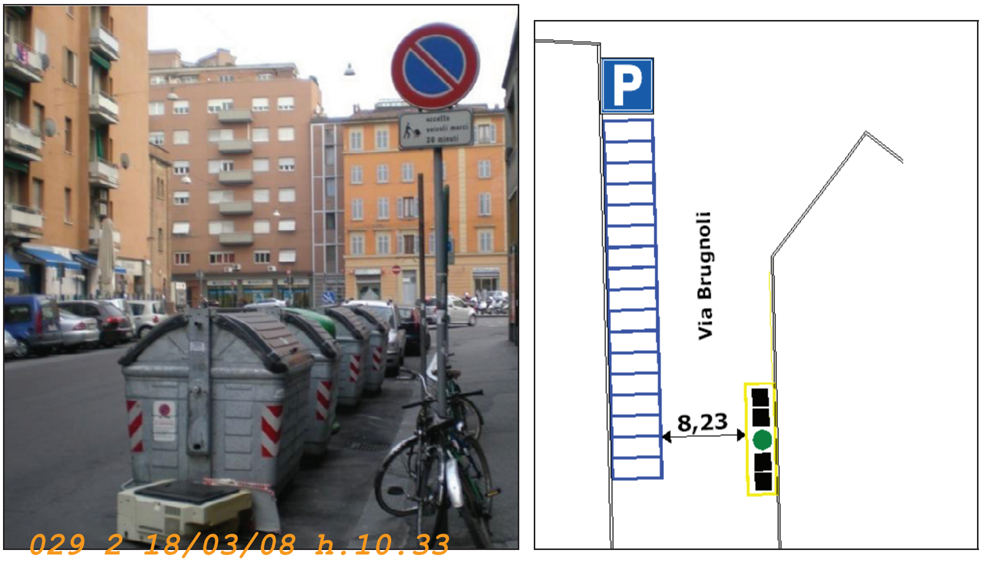


Figure 2 Example of parking stall occupied by bins

3.2. Data analysis

The main survey stated that the number of SCVLZs currently in the historical centre equals 415 units, organised in 175 MCVLZs of various dimensions. The average data in the periods surveyed show that:

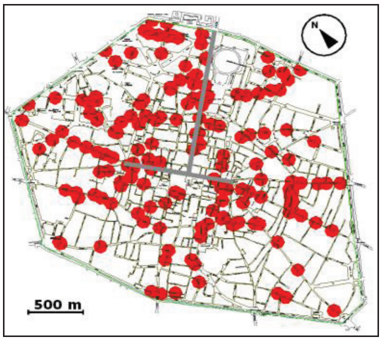
- 48 SCVLZs are occupied by hotels, bins, and sidewalk barriers,
- 213 SCVLZs are occupied by vehicles which are not authorized, and
- 154 SCVLZs are free or occupied by vehicles which are authorized for loading and unloading.

Excluding the first group from the analysis, which is in fact unsuitable for the l/u, the number of SCVLZs is equal to 367 of which 58% were illegally occupied during the survey. This data is in agreement with the outcome of the City of Bologna held in 2004 that 57% of available stalls were occupied inappropriately by unauthorized vehicles. In terms of numbers, it is easy, in light of the data to calculate a series of ratio's describing briefly the context of use of the existing MCVLZs. The relationship is calculated by comparing the total number of MCVLZs with those found free, occupied, free or partially occupied, and partially occupied or occupied. This was attributed to MCVLZ free or occupied by vehicles, even partially, by the term free and the MCVLZ occupied by unauthorized vehicles, the term occupied. The same principle was adopted for the partially occupied by unauthorized vehicles. The numbers calculated realize how, in the peak hour of business day on average, there is the actual scenario of the city logistics of Bologna, resulting not only from commercial traffic, but also for the number, type and location of MCVLZs and hours of access permitted for commercial vehicles.

Considering the MCVLZ as the distribution hub to serve a portion of the historic centre, you can approximate the area of influence of the MCVLZ like a circle. The estimate of the size of circular area served by a MCVLZ is based on an iterative process designed to approximate in terms of relationships, the same values calculated by the use of numerical relationships obtained earlier. Starting from a radius of influence of 70m, derived from interviews and questionnaires, we distribute the circles centred in MCVLZ, and the calculation continues by measuring the relationship corresponding to the number taking into account that the location of MCVLZ can involve the overlap of the circles corresponding to them.

The optimal radius of influence minimizes the averages compared to the corresponding numerical relationships. In Bologna's case we obtained an optimal radius of 50m, with corresponding average gaps of 5.5%.

By adopting this radius it is then possible to derive a data that compares the area covered by all the MCVLZ with the entire surface of the historic district. Figure 3 shows schematically the different areal ratios calculated.



Numerical relationships MCVLZ	
Free / Total	0.27
Free + Partly Busy / Total	0.61
Busy / Total	0.39
Busy + Partly Busy / Total	0.73
Area relationships MCVLZ with r = 50 m	
Free / Total	0.27
Free + Partly Busy / Total	0.57
Busy / Total	0.51
Busy + Partly Busy / Total	0.79
Historical center area	4,211,626 m^2
MCVLZ area of influence	1,030,820 m^2
Percentage of coverage	*24.48%*

Figure 3 Relationships between MCVLZs and historical centre map of Bologna

3.3. Study of optimization of SCVLZ

The logistic scenario of an urban area can be considered optimized when, for given type of spatial conformation, commercial trades and circulatory system, there is a 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.

By analyzing the existing logistical framework in the urban area under consideration, it is possible to judge the functionality, based on the values of the synthetic parameters described in the previous paragraph.

The judgement can be made for the logistics of the historic district as a whole or subdivided into zones. To do that, it is appropriate to establish the optimal conditions to be pursued for logistics in light of the spatial conformation, commercial trades and circulatory system, knowing that the process of optimisation can only be, due to the numerous parameters involved and their mutual relationship, of operative type. For example, relocation or downsizing of the SCVLZ would affect the commercial flows in a zone creating, in fact, a new logistics scenario.

We can operate optimizing, in this order:

i. the size of SCVLZs in relation to the type of commercial vehicles,
ii. the number of SCVLZs required to serve an area and the area under consideration because of existing commercial flows, and
iii. the location of SCVLZs in order to maximise the commercial stores serviced and to minimise the paths of vehicles in the area, in agreement with safety and the Road's Code.

3.3.1. Optimization on the size of SCVLZ

The types of commercial vehicles commonly used for freight transport in urban areas mainly differs by external dimensions and mass at full load. In general, the vehicles may be grouped as:

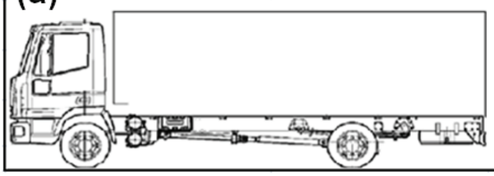
- vans (mass max: front axle = 1.3 ÷ 1.6 t; rear axle: 1.7 ÷ 1.9 t),
- box trucks (mass max: front axle = 1.8 ÷ 2.0 t; rear axle: 2.2 ÷ 2.4 t), and
- trucks (mass max: front axle = 3.1 ÷ 3.3 t; rear axle: 4.4 ÷ 4.8 t).

Table 2 shows the averages obtained from vehicle datasheets produced by various manufacturers. The choice of the type of vehicle with which to make a l/u within a historic centre is linked, primarily, to the type of commercial service or business affected by the operations of l/u and accessibility of the urban grid. That, subject to the size of the road sections and radius of curvature is sometimes affected by restrictions on the tonnage of vehicles entering in the historic centre. Table 3, divided by type of pass (A=Agents, DSG=Distribution Services by ownerships, DSV=Distribution Services by third parties, F=Commercial Stores in LTZ), shows how in the city of Bologna 76% of the vehicles entering on an average work week are comprised of vans. In keeping with the theory, the dimensions of the SCVLZ servicing one or more of the businesses in the area is subordinate to the dimensions of the largest vehicle carrying out loading and unloading operations.

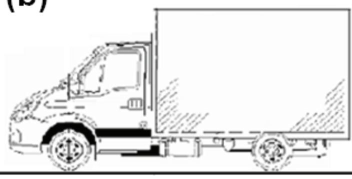
Table 2 Type of commercial vehicles and their specifications

Type	Weight [t]	Average length [mm]	Average width [mm]
Truck (a)	> 7.5	6,900	2,500
Box Truck (b)	3.5 < t < 7.5	5,900	2,200
Van (c)	< 3.5	5,400	2,000

(a)



(b)



(c)

Table 3 Number of daily commercial vehicles entry in LTZ

Type	*A*	*DSG*	*DSV*	*F*	**TOTAL**	
Trucks	2	54	89	1	146	8%
Box Trucks	0	137	163	17	317	16%
Vans	37	650	689	92	1,468	76%
TOTAL	**39**	**841**	**941**	**110**	**1,931**	**100%**

For this reason it should, in general, provide at least 3 types of SCVLZs, with the location, made according to the criteria of the following paragraph and should be tied to the location of the commercial services or businesses themselves.

It is possible to study the minimum dimensions of a SCVLZ that are able to accommodate the parking of a van, allowing the operator proper and smooth parking and manoeuvring of l/u. Commonly, a van is equipped with sliding side doors and rear doors: in the first case the process of opening makes a deviation from the dimensions of Table 1 of 0.2 ÷ 0.3m. Secondly, opening the door to pivot has a radius equal to the size of the door (0.8 ÷ 0.9 m) and sweeps an angle usually between 90° and 180°.

Moreover, for the purpose of the operations of l/u to be executed on 3 sides of the vehicle, additional spaces should be considered taking into account the average size of the packages, the l/u devices and of the activities performed by the operator. Through studies, these sample areas were estimated at 0.5 to 0.6m in the case of lateral opening and the order of 0.7 ÷ 0.8m to the rear opening. Figure 4 summarizes the sizes attributable to SCVLZs for vans as indicated above. In particular, it identifies a total length equal to 7.0 m and a width of 2.5 m.

The occupation of the parking stalls by the vehicle can be realized depending on the type of SCVLZ (parallel, 30° or 90°), the provision of packages inside the vehicle and the spaces and the element adjacent at the SCVLZ. An example is in slides prepared properly in the sidewalk adjacent to the parking stalls.

In Bologna’s case we see parking stalls with average size of 2.0 x 6.0m, corresponding to the size of a standard space for parallel parking of cars increase by 1.0 m in length. The comparison of this with the size of the above shows that there is a strong lack of functionality in the size of a SCVLZ of Bologna that not only limits the operation of parking and the operations of l/u, but leads to the illegal occupation of road space outside the SCVLZ.

The situation does not only affect the Bologna SCVLZs it also limits the manoeuvring of the parking and operations of the loading and unloading, causing the illegal occupation of public street spaces for SCVLZ, involving increased time for the loading and unloading and downgrading conditions of the road safety in the streets.

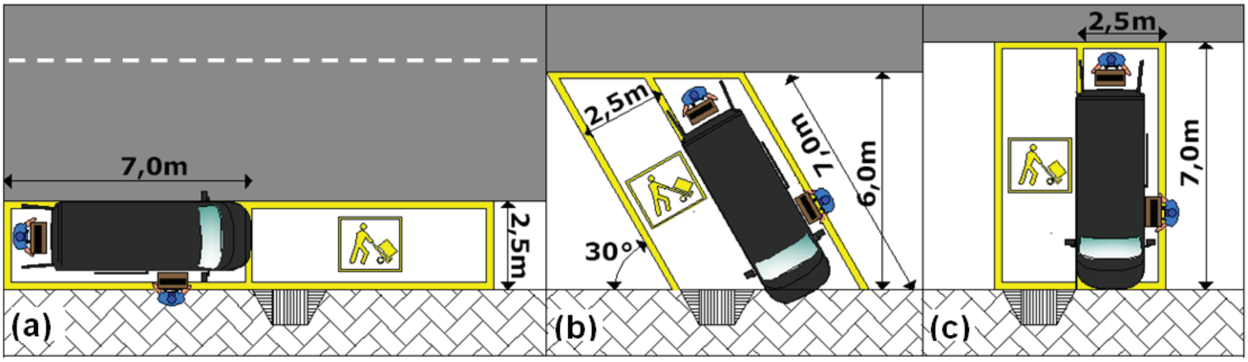


Figure 4 Type of parking stalls: parallel (a), 30° (b), 90°(c)

3.3.2. Optimization on the number of SCVLZ

The optimization process must focus on the assessment of the number of SCVLZs necessary for l/u stops made by all the vehicles present in the area within the adopted temporal unit. It is perceived that the number of SCVLZs estimated value is dependent on the demand of the loading and unloading in relation to trade flows input/output from the area of study.

The optimisation of the number of SCVLZs can be conducted through a homogeneous zone, like an urban area defined by a geographic contour and/or administrative, or like an urban area identifiable through the study of conformation and territorial road in its circulatory system.

Identifying the homogeneous area to study for the optimisation calculations for the number of SCVLZs, it is advisable to have some data derived mainly from traffic surveys and sample surveys, taking into account the time slot in which it is granted access to. The surveys commonly return the traffic flow of the input and output of commercial vehicles. The study allowed an estimate of the average number of operations (nl/u) performed in the area by a commercial vehicle and the average time (tl/u) needed to achieve a l/u, including time-shift used to arrive at the SCVLZ.

The Department of Mobility and Transport Emilia-Romagna Region (2005) conducted an investigation of the average number of commercial vehicles that pass under the electronic gates daily and enter the historic centre of Bologna from 07.00 to 20.00 (Figure 5).

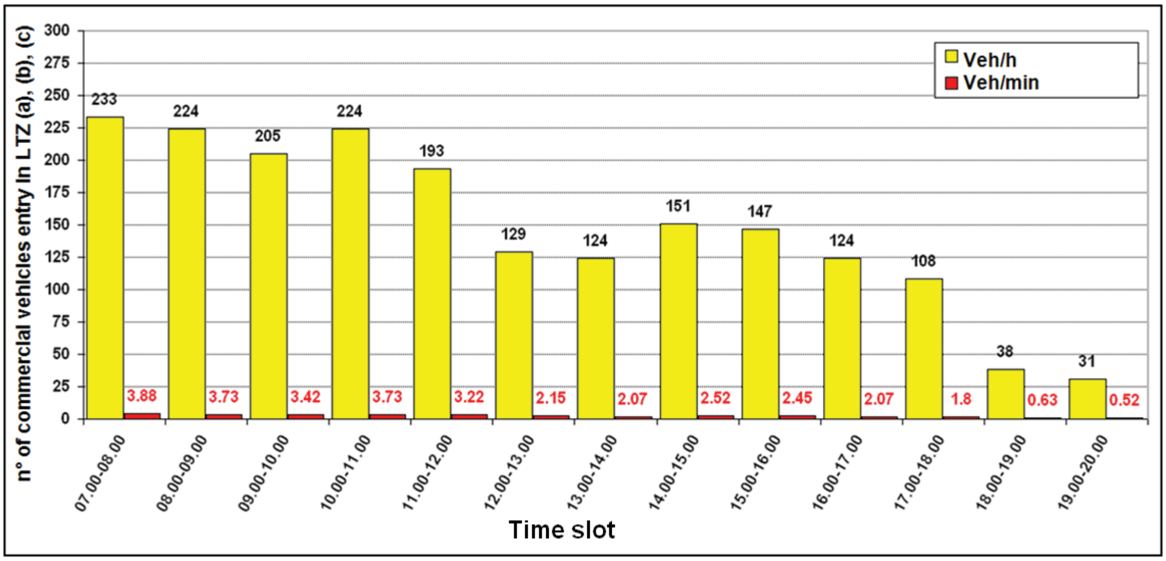


Figure 5 Number of commercial vehicles entries in LTZ

Moreover, the same study provided data for $n_{l/u}$ and $t_{l/u}$, respectively, equal to 15 operations l/u and 14 minutes. On the basis of the data set it can be calculated during the prescribed time (minutes, ¼ hour, ½ hour, hour), the cumulative number of entered vehicles occurred in the previous time period, equal to $n_{l/u} \bullet t_{l/u}$. This interval denotes the average period in which a commercial vehicle carries out $n_{l/u}$ operations, of each duration $t_{l/u}$. The graph in Figure 6 represents the curve of cumulative attendance of the inputs to the historic centre of Bologna, obtained by discrete intervals per minute as the time observed. The expression shown in the graph of Figure 6 calculates the number of visitors per minute x.

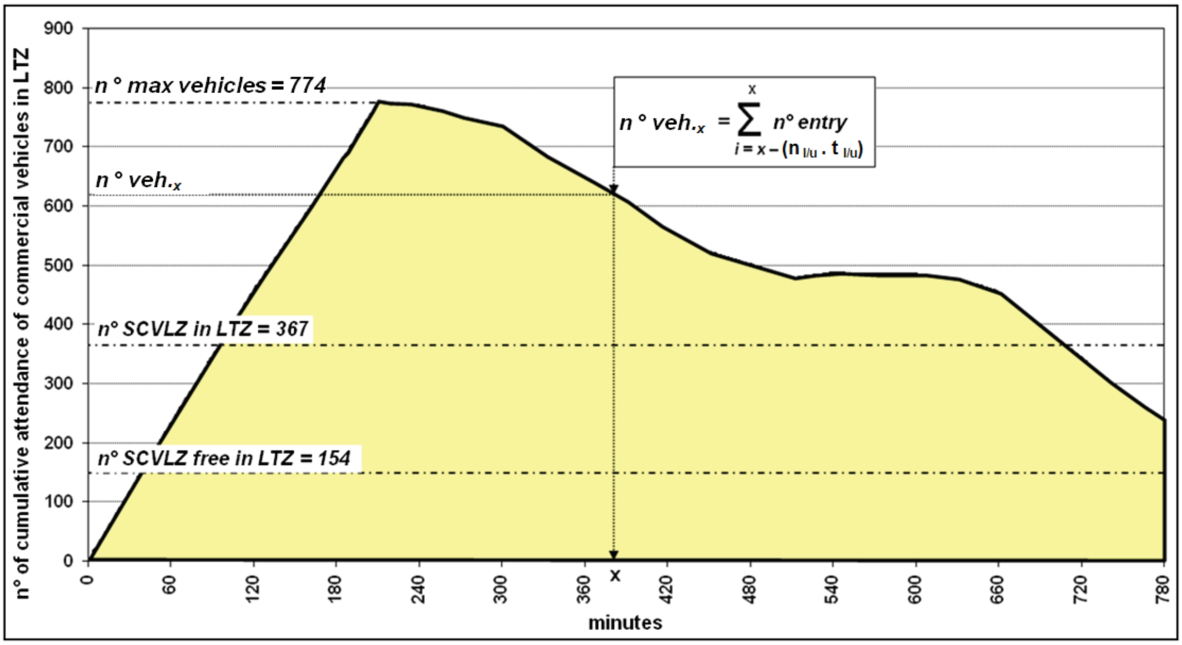


Figure 6 Number of cumulative attendance of commercial vehicles in LTZ

From this graph it is possible to identify a growing trend due to accumulation of vehicles carrying out deliveries/pick-ups in the early hours of the morning and remaining in the centre for a time equal to nl/u · tl/u. Note, how the size of nl/u and tl/u significantly affects the size of the range spent by vehicles, consequently, shown on the graph. The identification of the maximum number of commercial presence is already in the number of SCVLZ needed to meet the demand for a stop in the time window for access in the average weekday.

In order to size the number of SCVLZ with a maximum value depends on the availability of potential parking areas in the homogeneous zone. The optimisation process can conveniently provide for the fulfilment of only one part of the stop demand. The curves in Figure 7, obtained from the graph in Figure 6 by comparing the number of SCVLZs to the corresponding percentage of time that the demand is met, to identify, in Bologna's case, the number of SCVLZs which corresponds to a large increase in hourly coverage for a given increase in SCVLZs. This number is, in this case, estimated to be 485 units, equivalent to 49.6% coverage per hour. By comparing the data with the reality of Bologna, which has 367 SCVLZs (21.4% coverage per hour) potentially usable and 154 (5% coverage per hour) actually available, we realize how the current situation is not very responsive to the needs of commercial traffic that affects the historical centre daily.

Please note that a reduced number of SCVLZs does not correspond to a real reduction of commercial traffic, which is still carried by the operators and sometimes at the expense of safety and circulation efficiency. This example of Bologna highlights how the choice of the number of SCVLZs is required, as related to socio-economic assessments of the administration, dependent upon the curve of % coverage per hour, you can roughly choose a minimum value of the corresponding spaces at least 50% of hourly coverage.

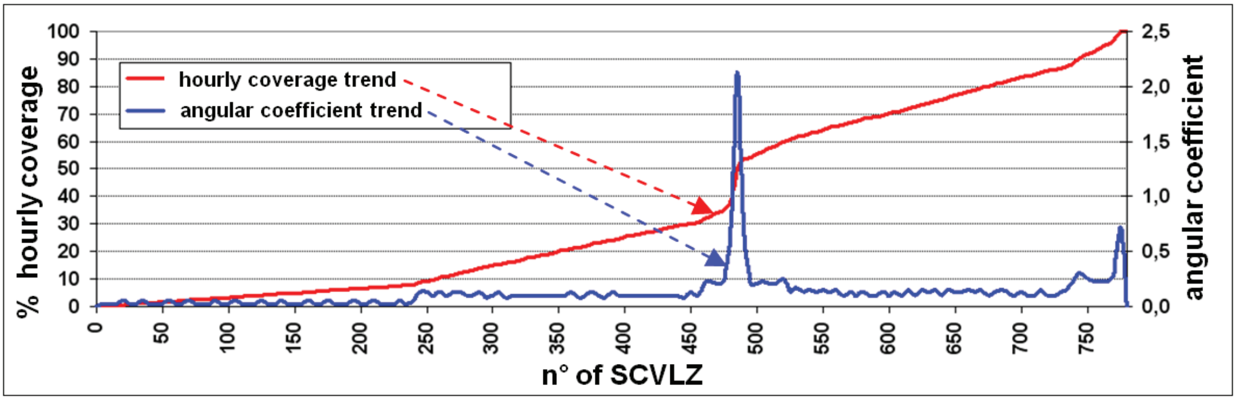


Figure 7 % hourly coverage of SCVLZ

3.3.3. Optimization on the location of SCVLZ

By optimizing the size of the SCVLZs and calculating the number of SCVLZs required for the homogeneous zone in question, it is possible to implement the optimization process in terms of location.

In general, this process requires that the engineer have available, in addition to information related to the area and the structure circulatory, details relating to:

i. the location and classification (type, size, etc..) of businesses in the area of interest, and
ii. D_{mt} maximum distance travelled from the SCVLZ, including the impedances (pedestrian crossings, gradients, architectural barriers), by an l/u medium operator, to make one operation of delivery/pick-up.

It is also helpful to know the location of spaces in the area that can be used for the location of the SCVLZ in respect to road safety and the regulations of the Road's Code. For the location of parking stalls required is possible to apply a method of location that provides the allocation to each business of a weight attractor/generator in terms of operations l/u, thus giving a synthetic representation of the density of the commercial area. This weight can be expressed, for example, with a number of equivalent commercial stores (NECS) with which to describe the logistic capabilities of various businesses.

The process of locating the stalls needed begins by placing them in the areas of higher commercial density and the criterion of location requires the maximization of NECS that can be served by staying in SCVLZ. This method can be improved by establishing a NECS beyond what is necessary to place near or adjacent to an existing location, to form a MCVLZ, one or more additional SCVLZ share it with one or more l/u paths.

To do that we have found the individual businesses located within the LTZ of the city of Bologna. A total of 3,634 businesses were divided according to the six sectors of trade (Department of Mobility and Transport Emilia-Romagna Region, 2005). We later characterized every business on the basis of the quantity and quality of deliveries it needs daily, taking into account the chain to which it belongs and the size of the business itself. In association with each chain there is a coefficient representative of the flow of goods generated by it taking into account the number of packages delivered, as well as the weight and dimensions of each package (Table 4).

Therefore, it was possible to derive for any MCVLZ the corresponding NECS. Each business or commercial service of every sector has a defined NECS. It was taken as the reference, the clothing's chain as it is in possession of smaller NECS, this number has been standardized for simplicity, the remaining chains are multiple of clothing's chain. The number of NECS corresponding to each sector is given in Table 4.

Applying this criterion to the businesses recorded, we can say that there are 17,279 NECS within the borders of Bologna, 8,542 of which (49.4%) not served by MCVLZ so as distributed. On average there are approximately 53 NECS for each MCVLZ, compared to the nearly 103 units that should be served by a MCVLZ (Table 5).

Utilizing the same number of MCVLZ, we have therefore tried to optimize the service offered by their relocation in order to serve the largest possible number of NECS.

Table 4 Number of NECS for every sector of trade

	Ho.re.ca.	Non Food	Clothing	Fresh	Dry	Frozen
N_{ECS}	1.5	3	1	4	5.5	1.5

Table 5 Average number and weight of packages for every MCVLZ

N_{ECS}	Number of packages	Total weight of packages (kg)
102.8	617.1	2,838.7

In some areas of the city, properly repositioning the existing sites, would increase total coverage of about 40% over the current situation.

Where the engineer does not have access to the information relating to i) and ii) it is necessary to implement a simplified process of location, based mainly on knowledge of the spatial conformation of the circulatory system and road network. The measurements and analyzed data collected in Bologna's case, returns the value of the radius of influence of the single SCVLZ (50 m). This radius is representative of the maximum distance that business operators are willing to travel.

If the study of optimization is implemented in an existing urban area it is plausible that the engineer is nevertheless aware of the broad location of commercial services in that area, may know, for example, on what roads have business locations and which of these have requested to the administration to achieve one or more SCVLZ nearby.

According to the simplified method the location of SCVLZ can begin with the location of requested SCVLZ.

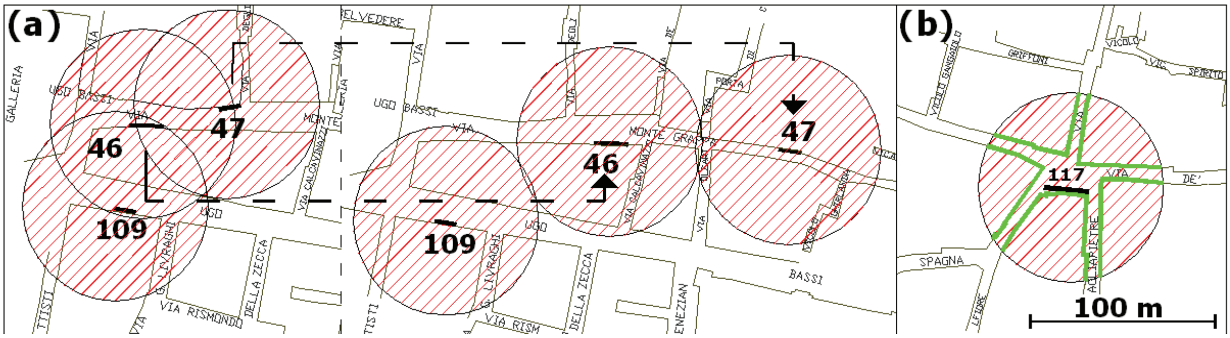


Figure 8 Examples of minimization of overlapping areas of influence of stalls (a) and of maximization of the front built covered (b)

The remaining spaces can be created to cover the entire commercial area, assuming a homogenous distribution of commercial fronts, according to the following criteria:

i. minimisation of overlapping areas of influence of stalls, and
ii. maximise the front buildings covered.

The application of the first method in the Bologna case has produced a relocation of 62 of 175 (including 38 reserved) compared MCVLZ existing applications of which, in all probability, was based on the localization of MCVLZ implemented by the municipality; recording an increase of 23% of the area covered.

To complete the process of location of SCVLZs in the historic centre of Bologna, you should also provide for the placement of 118 additional SCVLZs to meet the number of SCVLZs optimised calculated as above (485).

The location of existing sites in Bologna seems poor: the very fact that the small number of SCVLZs are not fully utilised in the half-peak indicates that, besides being small and few, they may also be badly placed. The encountered situations of irregular stops confirms that.

The methods of optimising the location of the SCVLZs presented here must be accompanied by assessment of the SCVLZs themselves into the circulatory system of the area. This is identifiable in accordance with the principle of minimizing transfer pathways in entry and exit from the area and among the SCVLZ located in the same.

This is linked to the issue of externalities produced by vehicles; by contributing to the overall congestion and emissions in the area. In light of this, to further refine the chosen locations it is appropriate to identify the appropriate vertical and horizontal traffic signs and the use of the routes that facilitate the movement of vehicles between the spaces.

Finally, it highlights the fact that any method of location of SCVLZs should be based on the principles of maintaining safety conditions, quality of circulation and, in short, the rules of the Road's Code as well as common sense.

4. Implementation and Verification of the Study

At the conclusion of the study, to maximise the parking spaces and their use in an existing urban homogeneous area, it is desirable to shift the phases of implementation and testing of interventions established. In light of the logistical scenario found in the stages of acquisition and analysis of important data, may therefore can be designed the size and the locations of SCVLZ required for the zone as described above. The new scenario, as designed, may induce a change of the components of trade flow in the entrance area, as well as changes in numerical order and the relationship of employment of the parking spaces, the average number of operations l/u completed by each vehicle ($n_{l/u}$) and the average time of operation ($t_{l/u}$). After a set time in which we admit that the rebalancing of distribution is possible, we therefore, make a survey for verification by which to decide whether, and under what terms, variations of parking spaces have resulted in a positive alteration of the total logistics scenario.

The survey of verification can conveniently use the data from the electronic gates (if present), the studies on the number and timing of the operations l/u and of the use of parking areas, with which trace, in this order: evaluation of the number of appearances of vehicles, the range of peak time, the hourly % coverage of the application stops, the number of employment relations, the corresponding areal ratios from which, finally, to recalculate the approximate radius of influence per MCVLZ. Whatever the economic trends for which the verification period does not allow substantive changes, it is possible to draw comparisons between the objective parameters calculated and those past, considering the trade flows and their daily distribution like a weight of the comparison. Subsequent refinements to the number and location of parking stalls based on criteria set out above will lead to economic equality for traffic, for optimising the operating logistics of the area for which, we remember, were considered unaffected conformation territorial but especially the attitude and circulatory accesses (time slots and vehicles allowed).

5. Conclusions

In order to develop a process of optimization of logistics which meets the basic principles of city logistics, it is desirable to have management tools which change the plans of parking regulations, not just in size, in the location and number of SCVLZs, but also, as far as possible, in the spatial configuration of infrastructure and into the circulatory system, with particular reference to the regulation of access and trade routes.

The application of innovative technologies to these concepts, some of which have already deployed in the city of Bologna, is directing towards the development of integrated management of logistics based on the real time acquisition, the intensity and type of trades in entry and exit (electronic gates), the assessment of the SCVLZs' use (cameras on-site), on the measurement of the masses of vehicles (WIM), the ability to manage access to the telecommunications centre, in order to optimize the commercial appearances to the number of SCVLZs actually available.

The next step to be developed will include the construction of freight hub adjacent to the homogeneous zone in question, with which a switch to a more streamlined logistic scenario is automated, like most modern industrial reality: ideas such as the construction of underground freight transport (CargoCap, Tubexpress, etc..) are already under investigation in several research centres worldwide.

For the logistic optimisation of the historic centre of Bologna we seek further stages of investigation conducted through surveys and studies on the ground, principally, to the quantification of the distances travelled by the operators and the zoning of the historic district in the sub-feature-based trade routes to the gate of entry in/out. It also intends to propose methods by which to discourage the misuse of parking l/u, which take, for example, concrete barriers and/or special signs or rising bollards. Finally, it is considered useful to provide a technical basis on which to base the maintenance of traffic signs, mostly horizontal, which take into account the visual assessment conducted during the surveys and of possible instrumental investigations based on regulations in reference (UNI EN 1436: 2007).

In conclusion, the city logistics are proposed as a high potential for the management of trade flows in an urban and suburban area. The objectives of rationalization plans and stop access for commercial vehicles in the service areas of historical vulnerable areas, must be accompanied by the reduction of externalities that they generate to the people and the environment. By contrast, the location of commercial activities in the areas of city centres draws vital flows to and from the outside. Even medium-sized cities such as Bologna may be significantly affected in their city-centre by the simultaneous presence of several hundred vehicles attempting to stop. The result is represented by congestion, failed deliveries/pick-ups and pollution that an adequate supply chain management of access and stops could mitigate or cancel.

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