A LOGISTICS CENTRE STRATEGY FOR THE MANAGMENT OF GOODS MOVEMENT AND FREIGHT VEHICLES ON THE ROADS OF THE CENTRAL REGION OF MEXICO

J. P. Antún, A. Lozano, R. Magallanes, F. Granados, R. Alarcón, A. Guzmán, L. Guarneros, L. Macías
Laboratorio de Transporte y Sistemas Territoriales
Instituto de Ingeniería
Universidad Nacional Autónoma de México (UNAM)
Torre de Ingeniería piso 2 ala norte, Ciudad Universitaria, México DF (04510) MEXICO
jantunc@iingen.unam.mx; alozanoc@iingen.unam.mx; rmn@pumas.iingen.unam.mx; fgranadosv@iingen.unam.mx; ralarconm@iingen.unam.mx; lguzmanc@iingen.unam.mx; lguarnerosa@iingen.unam.mx

ABSTRACT

This paper is focused on the movement of goods and freight vehicles in the Central Region of Mexico, which has a market of over 30 million inhabitants inside multiple cities forming the megalopolis.

The paper contains three main parts. The first part presents the general concept of Logistics Centre (LC) and the description of an Integrated Merchandize Centre (IMC). An IMC is a LC infrastructure which can be useful for improving the trucks flow in the Central Region.

The second part presents an analysis of the flow on the road network within the Central Region, which is based on traffic counts. The flow analysis includes total flow, trucks flow, trucks flow at “rush hour”, and trucks flow per vehicle type. Also, an analysis of the seven corridors which cross the Central Region is included.

The third part of the paper is focused on the following: i) the location of Strategic Logistical Nodes (SLN) in the Central Region; ii) the pre-feasible profiles for IMC; and iii) the possibility of using basic modules for the integration of different types of IMCs.

The analysis allowed indentify opportunity niches in industrial and services sectors which are important for the development of LC projects in the Central Region, and the best places for the LC location.

The main benefit of the implementation of LC in the identified SLN is the logistical territorial management which contributes to reduce congestion, travel time, land-use conflicts and emissions.

1. INTRODUCTION

The Central Region is located in the heart of Mexico and is formed by six states: Federal District, Mexico State, Morelos State, Puebla State, Tlaxcala State and Hidalgo State (see Figure 1).

Nearly 30 millions of inhabitants are distributed in the Central Region, especially within the main cities: the Metropolitan Zone of Mexico City (MZMC), Toluca, Puebla, Cuernavaca, Pachuca and Tlaxcala (see Figure 2). The MZMC has over 20 millions of inhabitants (consumers) and a high concentration of productive and service activities, which require a

large amount of freight transportation. The MZMC is located in the Federal District and the Mexico State (almost half/half).

The main background of this research is the following: i) a general review and classification of logistics centres, based on Mexican and international experience, particularly the European situation [1, 2, 3]; ii) a previous study confined to the MZMC and the first ring of urban expansion [4, 5, 6]; and iii) the analysis of new trends on the physical metropolitan distribution of goods [7].

The paper is divided in the following sections. The concepts of Logistics Centre (LC) and a description of Integrated Merchandize Centre (IMC) are presented in Section 2.

Section 3 presents an analysis of the flow on the road network of the Central Region. This analysis is based on traffic counts (Annual Average Daily Traffic, AADT) and includes: total flow, trucks flow, trucks flow per lane, trucks flow at “rush hour”, and trucks flow per vehicle type. The distribution of the freight trucks flow on the road network of the Central Region and on the National Corridors (which cross the Central Region) is analyzed. Bottlenecks on the road network of the Central Region are identified, and the main internal corridors in the Metropolitan Zone of Mexico City (MZMC) are listed.

Section 4 is focused on the identification of Logistics Nodes in the Central Region. First, the Strategic Logistical Nodes (SLN) are identified in the territory; later, the products and services which have presence in LC are listed; then, pre-feasible profiles and strategic proposals for the development of LC and for the integration of a portfolio of LC projects are presented; also, the possibility of integrating different types of IMC with base on basic modules is introduced.

Finally, conclusions and references are presented.

Figure 1 – Location of the Central Region of Mexico

2. LOGISTICS CENTRE AND INTEGRATED MERCHANDIZE CENTRE

2.1. Logistics Centre (LC)

A Logistics centre (LC) is a suitable territory for the development of logistical activities. It includes an appropriate lay out for efficient trucks movement, logistical naves with platforms, truck parking areas, infrastructure for intermodal transfers (in certain cases), buildings for logistics operator offices, and buildings for complementary services for trucks (maintenance shops, service stations, spare parts distributors, etc) and operators (coffee shops, restaurants, hotels, etc). In some cases, buildings for complementary services are also required: business centre with meeting rooms and classrooms, bank services, governmental agencies services (customs, sanity controls, etc), exhibition centre, etc.

Logistics centres are very important for improving the following:

a. Management of load units
b. Management of modal transfers
c. Processing of order, with cross-docking and management of delivery transport
d. Stock storage, orders prosecution and delivery management
e. Added value operations for the goods adaptation to final clients (customisation in logistical post-finish)
f. Stock storage into customs ("in-bond")
g. Stock storage as a "secured guarantee" for bank loans which are dedicated to operation capital
h. Urban territorial logistical management and regional competitive territorial logistical management

A classification of LCs was presented by Antún et al., (2008) [1]. The main characteristics of the types of LC are described below:

i) An Integrated Merchandize Centre, IMC (freight trucks consolidation centre), is oriented to improve transportation operations; usually, it is an instrument to transfer terminals from the urban network to the outskirts. They require good access to the highway system.

ii) An Urban Logistics Micro-Platform, ULMP (orders load centre), facilitates the physical distribution of finished goods, in urban areas with restricted roads (for example, historical centres with restricted schedules), and supports short cycle operations, providing an adequate supply to the points through small daily deliveries.

iii) A Corporative Logistics Platform, CLP (logistics park), includes facilities for physical distribution, and is established by big companies according to their interests (for example, the distribution centre of a big departmental store).

iv) An Inter-modal Logistics with Railway Platform, ILRP (inter-port), has the same nature of an IMC, but it is specially oriented to multimodal transportation, transferring from truck to railroad and vice versa.

v) A Logistics and Transportation Service Centre (LTSC) is oriented to improve the logistics competitiveness of a specific industrial sector, supporting the 3PL's performance.

vi) An Air Cargo Logistics Centre (ACLC) is a LC located in an airport area with gateway and hub characteristics (ACLC in first and second line), or out of the airport but within the closer hinterland and with good accessibility to the airport (CLCA third line).

vii) A Port Logistical Activities Zone (PLAZ) is a LC located in a marine port with gateway and hub characteristics, and important intermodal infrastructure.

viii) A Mega-Distribution Logistics Platform (MDLP) is LC focused on the metropolitan or trans-border mega-distribution.

LC projects are been frequently incorporated to the plans and programs for urban-metropolitan territorial management, due to the generated positive externalities related to the management of trucks flow. A LC facilitates centralized distribution strategies for reducing fleet size and congestion on urban road networks, and then for the mitigation of local and global emissions.

A LC is also a real estate development business, as the industrial parks (equipped territory for industrial activities).

2.2. Integrated Merchandize Centre (IMC)

An Integrated Merchandize Centre (IMC) (or freight trucks consolidation centre) is a LC for improving the road freight transportation operation. Usually, it is an instrument to transfer the freight terminals from the urban area to the outskirts where the access to the freeway network is easy. Also, an IMC is used in the border areas where the transportation vehicles of a country are not permitted in the neighbouring country (for example, the articulated trucks of Mexico are forbidden in Central America, and the RENFE train wagons of Spain cannot access the rail network of the rest of Europe because a different trail).

For the success of an IMC, certain basic conditions should be satisfied:

- Its location should be strategic in terms of accessibility to the freeway and highway network, and the urban-metropolitan freight transportation corridors; in case of trans-border operation, its location should be strategic respect to the border crossing.

- It requires the participation and impulse from the regulatory transport authority, and the participation of the municipality and local community, leading transportation companies, a key logistical operator for industrial packing; and leading freight and tariff agents (in case of trans-border operation).

Some of the most representative examples of IMC are the Transportation Centre of Madrid (Spain), the Integrated Merchandize Centre of Vallés (in the metropolitan zone of Barcelona, Spain), and SOGARIS (in Rungis, a suburb on the northern part of Paris, France).

The main characteristics of an IMC are the following:

- It is focused on road transportation companies, logistical operators for the consolidation of road interurban transportation, and logistical operators for urban goods distribution.

- It must have excellent links to the highway network for the connexion to the national road corridors which are used by large articulated trucks, and to the urban freight transportation corridors which are used by freight vehicles for the line-haul link of the urban physical distribution of goods, following the urban regulations on dimension and weight.
- It is useful for the articulation of line-haul links and urban delivery paths, on supply chains.
- It allows have logistical infrastructure with naves, essentially for cross-docking without inventories (with a free height to the ceiling which can be lower than 10m, and with standard specifications for the floor resistance); with a lay-out where at least 60% of the surface is dedicated to roads. The infrastructure can be modularly developed on a typical 35 hectares surface.
- It can include sets of complementary services for companies (business centre and exhibitions centre), operators (coffee shops and restaurants, gyms and hotels), and vehicles (spare parts shops, fuel stations, clean service).

A network of IMCs, which is located in a system of cities, has the following advantages: i) large vehicles do not need enter into the city; ii) capillary distribution can be carried out using appropriate vehicles for the urban area; iii) the metropolitan urban physical distribution can be centralized, which can diminish the number of vehicles, their paths, and hence congestion and local and global emissions.

If a program of IMC with public-private participation (in strategic locations within the system of metropolitan highways, rings and freeway) is not promoted, then the entrance of large trucks to Latin American cities cannot be restricted. Such restriction without an IMC program could produce supply collapse and increase of logistical costs.

The mentioned program of IMC projects is needed by metropolitan areas of large magnitude (as the Metropolitan Zone of Mexico City, the Large Buenos Aires, the conurbation of the Federal District in Caracas, and Bogotá). Such program must be based on the identification of Strategic Logistical Nodes (SLN) and the exploration of Reserve Areas for Logistical Activities (RALA) [6, 8].

The public participation is the identification of the SLNs, the implementation and land-use protection of the RALAs in the SLNs, and the improvement of the road network which connects the SLNs. The private participation is the investment on logistical real estate developments in the SLNs.

The IMC is a LC infrastructure which can be very useful in the Central Region of Mexico.

3. ANALYSIS OF THE FLOW ON THE ROAD NETWORK

The Communications and Transports Secretary (in Spanish, Secretaría de Comunicaciones y Transportes, SCT) publishes information about traffic counts on the primary road network of Mexico.

An analysis of traffic volumes in the Central Region, based on the SCT traffic counts information [9], is presented in this section. The analysis includes the following: total vehicular flow, freight vehicle flow, freight vehicle flow per lane, freight vehicle flow at rush hour, and freight vehicle flow for each type of truck. The main road segments which are

used by each type of truck were identified. Also, the road segments which form bottlenecks for trucks and general traffic were identified.

The 13 main corridors in Mexico were analyzed; seven of them are incident to the Central Region. The main road segments of such corridors which are used by freight trucks were identified.

3.1. Flow on the road network in the Central Region

The identification of the road segments with the highest number of freight trucks, in the Central Region, was based on the traffic count information (Datos Viales 2008), which contains the Average Annual Daily Traffic (AADT) for several road segments; this information is classified according the type of vehicle (see Table 1).

Information of the K´ factor is also included; this factor is useful to determine the traffic (flow) per hour. The information is an approximation to the real value, and it is obtained as the rate of the highest traffic obtained from a sample of weekly traffic counts, and the AADT. Factor K' is used in this research for obtaining the estimated flow at rush hour.

In this section, an analysis of the geographic distribution of the AADT on the primary road network in the Central Region is presented (where information is available). The AADT is represented by means of maps, where the road segment wide indicates the AADT.

The AADT includes cars, buses and freight trucks on the primary road network. The road segments with the highest AADT values are the following: the México-Toluca toll highway, the San Pedro Barrientos-Ecatepec highway and the Puente Grande-San José del Vidrio highway; all of them have over 37 500 vehicles. A second place, with between 37 500 and 18 750 vehicles, corresponds to the México-Querétaro toll highway, the México-Cuernavaca toll highway, the México-Puebla freeway, the México-Puebla toll highway, the México-Toluca freeway, the Tlalnepantla - San Gabriel freeway and the Naucalpan-Toluca highway.

The AADT of trucks (AADTT), i.e. AADT corresponding to the C2, C3, T3S2, T3S3, and T3S2R4 types, represents nearly 5% of the AADT. The road segments with the highest AADT of trucks are located around the Federal District (one of the two States forming the MZMC); such segments correspond to the following roads: the San Pedro Barrientos-Ecatepec freeway (16 100 trucks), the México-Toluca highway (12 700 trucks), the Naucalpan-Toluca highway (10 300 trucks), the México-Querétaro highway (between 8300 and 6 300 trucks), the Tlalnepantla-San Gabriel freeway and the Los Reyes-Zacatepec freeway (5 500 trucks). Figure 2 shows the AADTT; freight trucks are mainly on the northern part of the Federal District.

The road segments with the highest AADTT for each type of truck are located around the Federal District, for each type of truck. Trucks types C2 and C3 mainly travel on roads located on the northern and north-western parts of the Federal District (in the Mexico State) on the roads which connect the MZMC and Toluca city.

The most used roads by articulated truck are also located on the most used roads by all types of trucks. Daily, over 1 000 very large trucks (T3S2R4) use the following roads: the San Bernardino-Tepexpan freeway, the San Pedro Barrientos-Ecatepec freeway, the Naucalpan-Toluca toll highway, the México-Querétaro toll highway and the Los Reyes-Zacatepec freeway.

The San Pedro Barrientos-Ecatepec freeway has over 7 500 trucks per lane. The nine roads with over 1 500 trucks per lane are the following: the México-Toluca highway, the Naucalpan-Toluca highway, the Tlalnepantla-San Gabriel freeway, the Los Reyes-Zacatepec freeway, the Santa Bárbara-Izucar de Matamoros freeway, the México-Querétaro toll highway, the México-Puebla highway, the México-Pachuca highway and the Toluca-Morelia highway.

Figure 3 shows the AADTT per lane on the primary road network. The roads with the highest rate are located around Mexico City. An interesting finding is that some of the most used roads have just two lanes for both directions, as some segments of the Los Reyes-Zacatepec freeway.

The Maximum Demand Hour (MDH) is usually called rush hour and corresponds to the maximum number of vehicles crossing a point on the road or a road segment during 60 minutes. Here, the estimation of traffic at rush hour is based on the AADT and the K´ factor, and it is called MDH-AADT (for all types of vehicles, including cars, buses, and trucks).

The roads with over 5 000 vehicles at rush hour are the Puente Grande-San José del Vidrio highway and the San Pedro Barrientos-Ecatepec highway. Some segments of the México-Toluca highway have over 3 000 vehicles at rush hour.

The highest MDH-AADTT (considering C2, C3, T3S2, T3S3 and T3S2R4 trucks) corresponds to the following roads: the México-Toluca highway, the San Pedro Barrientos-Ecatepec freeway, the Naucalpan-Toluca highway, the México-Querétaro toll highway and the Los Reyes-Zacatepec freeway. They have over 500 trucks at rush hour (see Figure 4)

The MDH- AADTT per lane gives a good idea about the deficiencies of the road network. Hence, the highest number of trucks at rush hour per lane is located on the following roads: the México-Toluca highway, the San Pedro Barrientos-Ecatepec freeway, the Naucalpan-Toluca highway, the México-Querétaro toll highway and the Los Reyes-Zacatepec freeway.

The Arco-Norte highway is a new road in the Central Region; there was not information about the traffic on it, hence it is not in this analysis. However, now it is an important road for freight transportation; it has three lanes in each direction.

Table 1 - Types of vehicle considered in the traffic counts

Type of vehicle	Description
A	Car
B	Buses
C2	Non-articulated 2 axes truck
C3	Non-articulated 3 axes truck
T3S2	Articulated truck (3 axes) with trailer (2 axes)
T3S3	Articulated truck (3 axes) with trailer (3 axes)
T3S2R4	Doubly-articulated truck (3 axes), a trailer with 2 axes and other with 4 axes
Other	Any other freight truck

Source: Datos Viales 2008 (DGST-SCT, 2008)

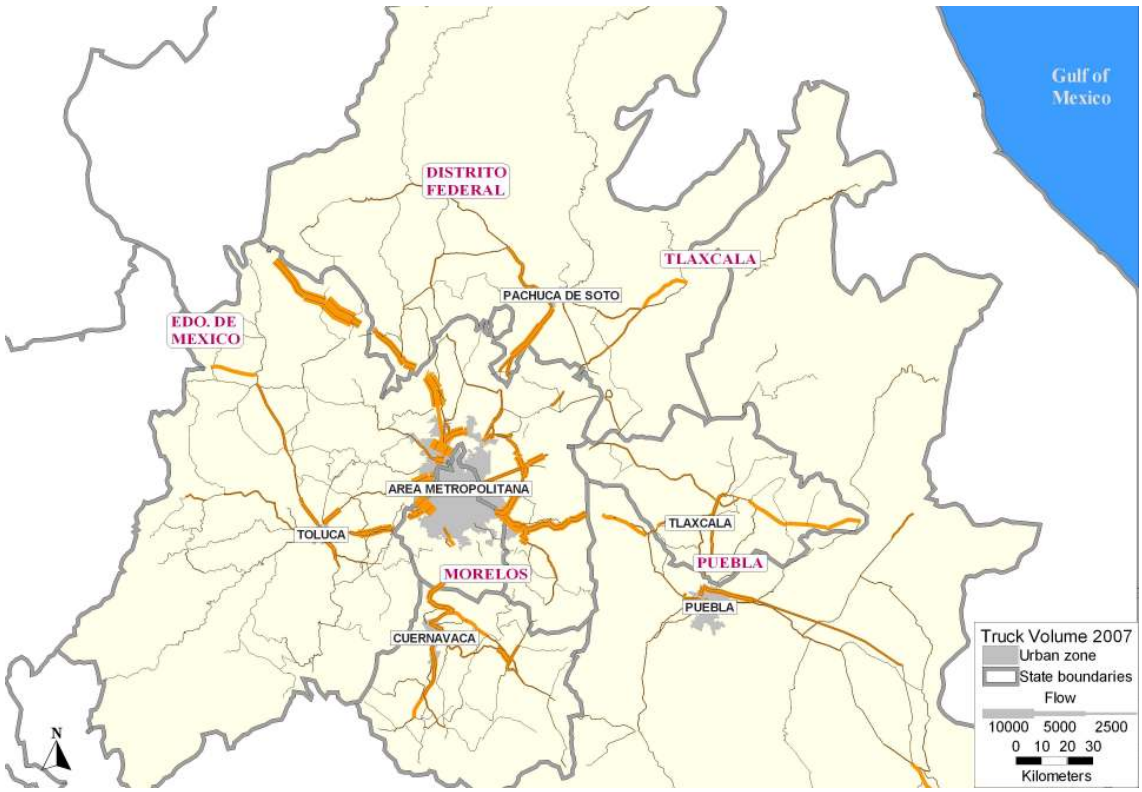

Figure 2 – The AADT of trucks on the primary road network in the Central Region

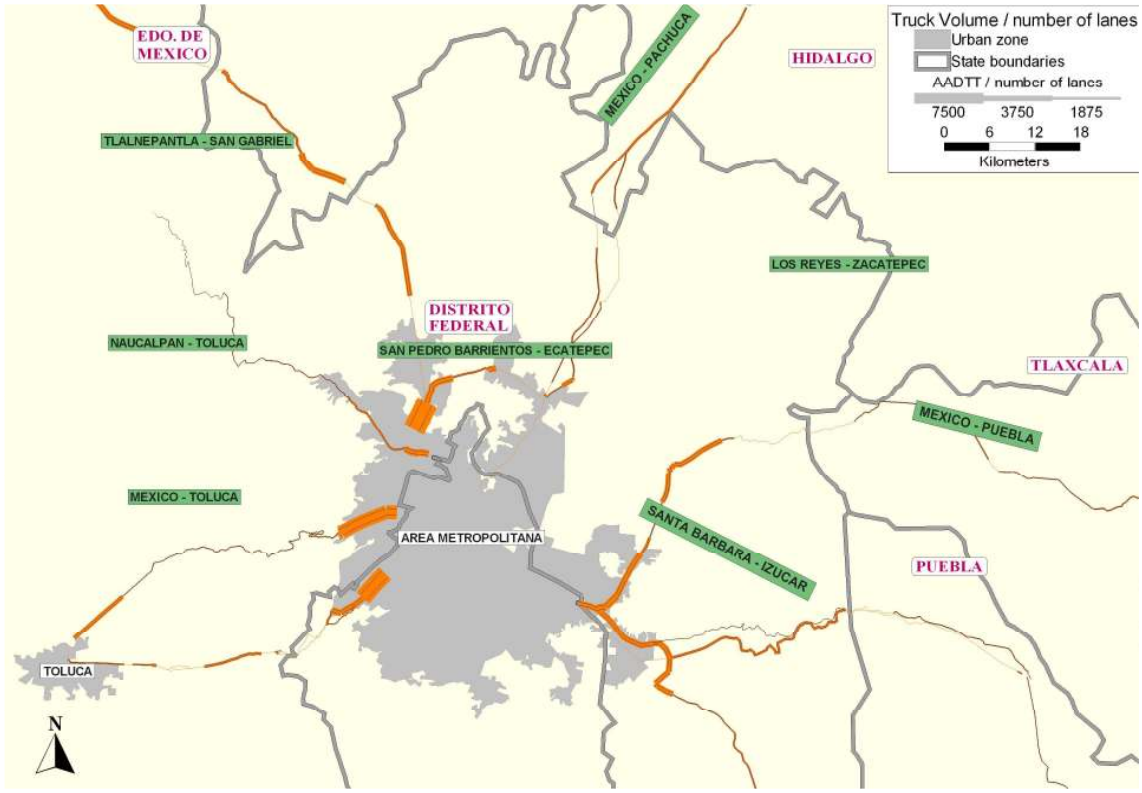

Figure 3 – The AADT of trucks per lane on the primary road network into and around the MZMC

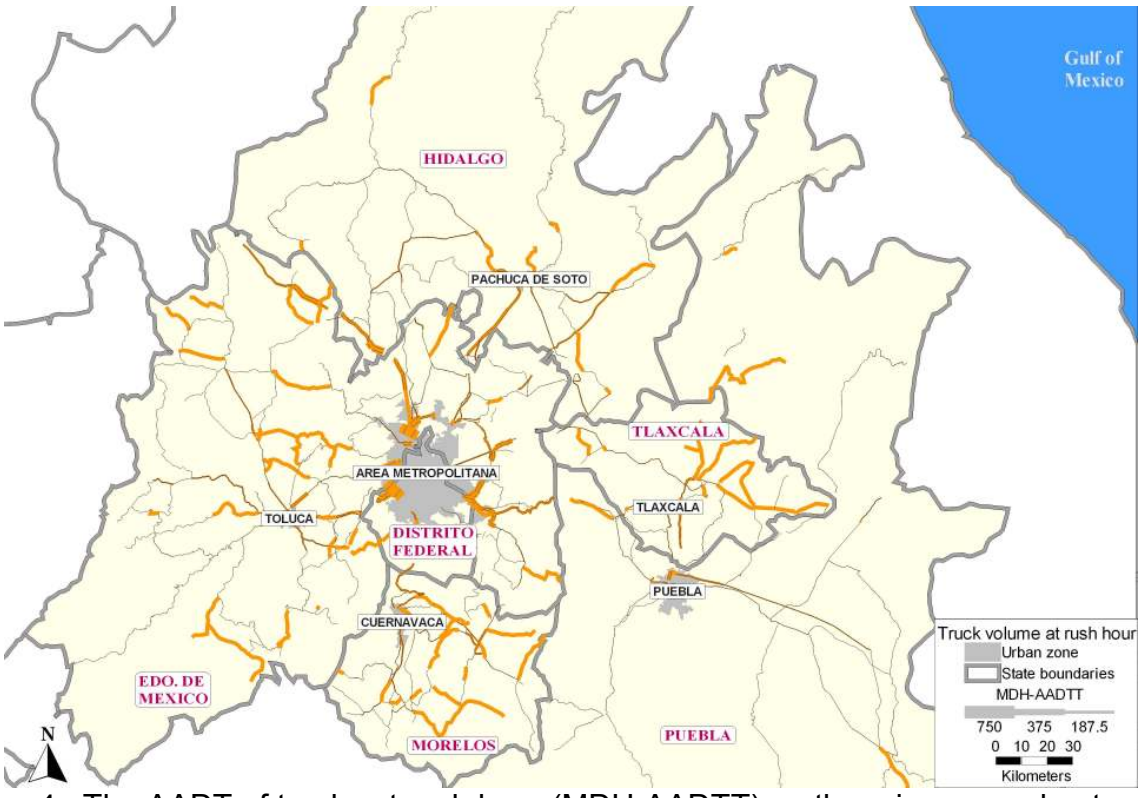

Figure 4 –The AADT of trucks at rush hour (MDH-AADTT) on the primary road network in the Central Region

Figure 5 –AADT of trucks on one of the corridors with connexion to the Central Region

3.2. Flow on the corridors which cross the Central Region

There are 13 main corridors in Mexico; seven of them have connexion with the Central Region. The main segments of such corridors, which are used for freight trucks, were identified according the type of truck and for rush hour. The corridors are the following: Acapulco – Veracruz, Altiplano, México – Tuxpan, México – Puebla – Progreso, Puebla – Oaxaca –Cd. Hidalgo, México – Nuevo Laredo and México – Nogales, Ramal a Tijuana. An example of the AADT of trucks is shown in Figure 5; it is a corridor on the north-eastern part of the country.

All of the corridors have a similar distribution of the AADTT, i.e., the roads with highest truck traffic are located near the MZMC.

3.3. Identification of bottlenecks on the road network of the Central Region

The list of the roads with the highest number of freight trucks is almost the same that the list of roads with the highest number of freight trucks per lane; the main difference between such lists is the ranking of the roads (see Table 2). Some roads have few lanes in comparison with other road with similar trucks traffic; such is the case of the Tlalnepantla-San Gabriel freeway and the Los Reyes – Zacatepec freeway.

The roads with the highest number of freight trucks per lane, at rush hour, are the following: the México-Toluca highway, the San Pedro Barrientos-Ecatepec freeway, the Naucalpan-Toluca highway, the México-Querétaro toll highway, and the Los Reyes-Zacatepec freeway.

For the mentioned roads, some actions must be taken; for example, improving their capacity (if it is possible), or giving road alternatives or territorial management measures for the urban road segments.

3.4. Main internal corridors in the Metropolitan Zone of Mexico City (MZMC)

The roads with the highest trucks traffic are mainly concentrated into and around the MZMC.

In a previous study [4], the main freight transportation corridors within the MZMC were identified and classified according priority respect to the needs of the freight transportation movement. One of the recommendations was to improve a set of corridors.

The high priority corridors which require important and fast attention, due to their improvement would contribute to improve freight trucks mobility, are the following: the eastern link of the Periférico urban freeway, the northern link of the Periférico urban freeway, the eastern link of the Circuito-Interior urban freeway; the pair of avenues Vallejo and 100 Metros; the pair of avenues Eje 5 and Eje 6 Sur (from Zaragoza to Central de Abasto); and the México-Texcoco freeway (from the Mexico-Puebla freeway to the Peñón – Texcoco toll highway).

Such corridors are forming part of internal rings (Periférico, Circuito Interior and México-Texcoco) or are located in industrial land-use areas or near the General Market of Mexico City.

AADT of Trucks (AADTT)	AADTT per lane
San Pedro Barrientos-Ecatepec • San Pedro Barrientos - Lechería-. Tultepec- Tepexpan (Ent. Guadalupe Victoria)	**San Pedro Barrientos-Ecatepec** • San Pedro Barrientos - Lechería-. Tultepec- Tepexpan (Ent. Guadalupe Victoria)
México-Toluca • México-Ent. Constituyentes y Reforma - Cuajimalpa (1 Acceso) • Huixquilucan-X. C. Amomolulco-Stgo. Tianguistenco	**México-Toluca** • México-Ent. Constituyentes y Reforma - Cuajimalpa (1 Acceso) • Lerma - San Pedro Tultepec - San Mateo Atenco (Alta)
Naucalpan-Toluca • México-Querétaro (Cuota) (Paso Inferior) -Loma Linda	**Naucalpan-Toluca** • México-Querétaro (Cuota) (Paso Inferior) -Loma Linda • El Cerrillo-T. C. Toluca-Palmillas.
México-Querétaro (Cuota) • Caseta de Cobro Tepotzotlan - Ent. Jorobas • Lim. Edos. Term. Hgo. Ppia. Mex. -X. C. Jilotepec-Maravillas-Aculco • Lim. Edos. Term. Mex. Ppia. Hgo .- Tepeji del Río	**Tlalnepantla-San Gabriel** • Tlalnepantla-X. C. México-Querétaro (Cuota)
Tlalnepantla-San Gabriel • Tlalnepantla-X. C. México-Querétaro (Cuota)	**Los Reyes-Zacatepec** • México-Puebla (Libre)- La Magdalena- Chimalhuacan • San Bernardino -Tepexpan -Texcoco -Tepetlaoxtoc
Los Reyes-Zacatepec • México-Puebla (Libre)- La Magdalena- Chimalhuacan • San Bernardino -Tepexpan-Texcoco -Tepetlaoxtoc	**México-Querétaro (Cuota)** • Caseta de Cobro Tepotzotlan - Ent. Jorobas • Lim. Edos. Term. Mex. Ppia. Hgo.- Tepeji del Río - T. Izq. Jilotepec - X. C. Jilotepec-Maravillas • Lim. Edos. Term. Hgo. Ppia. Mex.-X. C. Jilotepec-Maravillas
San Bernardino-Tepexpan • T. Der. Texcoco -X. C. Chinconcuac-San Francisco Acuexcomac	**Santa Bárbara-Izucar de Matamoros** • México-Puebla (Libre)- México-Puebla (Cuota) –Chalco
Santa Bárbara-Izucar de Matamoros • México-Puebla (Libre)- México-Puebla (Cuota) –Chalco	**México-Puebla (Libre)** • Lim. Edos. Term. DF. Ppia. Mex.-T. Der. Chalco
México-Puebla (Libre) • Lim. Edos. Term. DF. Ppia. Mex.-T. Der. Chalco	**México-Pachuca (Libre)** • T. Der. Pirámides -Venta d e Carpio -T. Der. Autopista México - Tecamac • Cuota C. México-Tizayuca (Cuota)-Ent. Colonia

Table 2 – Ranking of the main roads with the highest number of freight trucks, and those with the highest number of freight trucks per lane

4. LOGISTICS NODES IN THE CENTRAL REGION

This section is focused on the following: i) the location of Strategic Logistical Nodes (SLN) in the Central Region of Mexico; ii) pre-feasible profiles and strategic proposals for the LC development; iii) strategic proposals for integrating a portfolio of LC projects for the Central Region; and iv) basic modules for the integration of different types of IMCs

4.1. Location of Strategic Logistical Nodes (SLN) in the Central Region of Mexico

A set of 19 preliminary explored nodes were identified around important cities (Metropolitan Zone of Mexico City, Toluca, Tlaxcala, Cuernavaca-Cuautla) and the Arco-Norte highway (see Figure 2).

The identification of Strategic Logistical Nodes (SLN) was based on the following [2, 3]:

1) an analysis of the flow of freight vehicles, with base on traffic counts information, per type of vehicle and road segment (section 3);
2) an analysis of the rail connections according concessionaires;
3) an estimation of the traffic which is derived from the marine freight in the Ports of Veracruz, Tuxpan, Lázaro-Cárdenas and Manzanillo;
4) an analysis of opportunities in the accesses of the Arco-Norte and Circuito-Mexiquense highways and the new regional highways.

The identified SLN are presented in Figure 6. Potentially available plots (30/40 Ha modules) were explored for each SLN, with base on the processing of panchromatic and multi-spectral image mosaics of SPOT satellite, and the verification by means of field work using GPS.

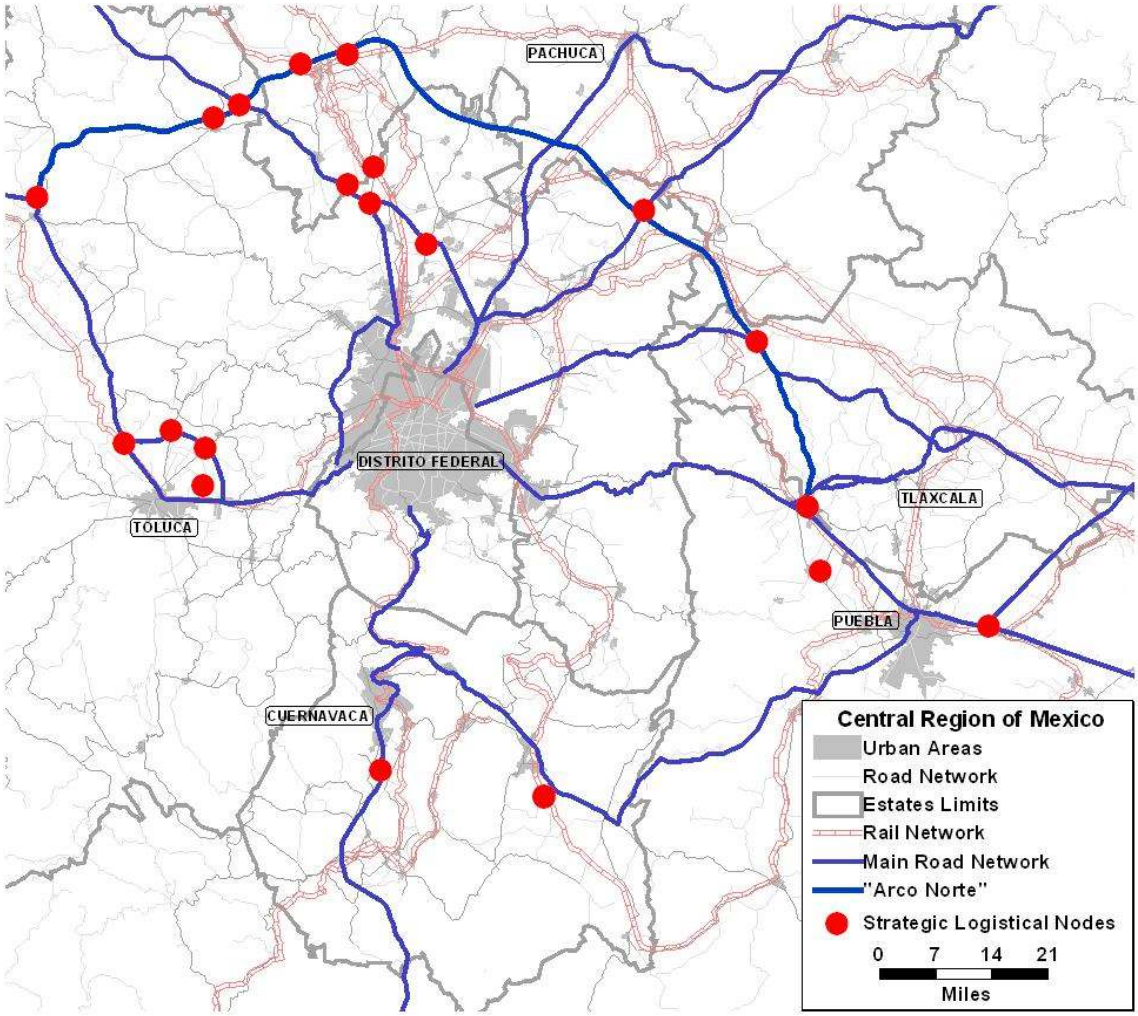

Figure 6- Strategic Logistical Nodes (SLN) within the Central Region

In any case, an exploration of plots was carried out to define RALAs, which could be integrated to a “Land Fund”. The accessibility for freight vehicles was also studied. The geographical and attributes information of the current LCs and the proposed SLNs was included in a Geographical Information System (GIS).

4.2. Presence of products and services in Logistics Centres

Opportunity niches in outstanding sectors of industrial activities and services, for the induction of specific LC projects, were identified. The identification was based on: i) the analysis of activity sectors of the companies which are located in each LC in the Central Region; ii) the analysis of the companies which are installed in each type of LC in Spain (a technical visit in Spain was carried out). The opportunity niches were classified in products and services.

The products in LC are the following: footwear (men, women fashion, children, and sport); hardware store products; pharmaceutical products; food for pets; printing and stationery products; products for offices; frozen products; items for hospitals; plumbing items; furniture and linings for bathrooms and kitchens; disks and dvds; distribution centres for restaurant or coffee-shop franchises; hotel and restaurant suppliers; spare parts for cars; wine and liquor distributors; distributors of carpets and mats; distributors of cloths, distributors of natural, dietary and ethnic food; candies, goodies and food for children; furniture; computer equipment; electrical material; domestic small tackles; cosmetics and

beauty products; items for cleaning; paintings; costumes; underwear; telephone items; milky products.

The transport and logistics services in LC are the following: goods reception centre, for chains belonging to supermarkets and department stores; distribution centres for restaurants or coffee shops franchises; processing centres for logistics operators whose speciality is fashion casual clothes sold to sell points chains; depot warehouses; facilities for freight agents (for consolidation/un consolidation, inspection, etc); terminals for freight transportation companies; and terminals for industrial packing logistics operators.

4.3. Pre-feasible profiles and strategic proposals for the LC development in the Central Region

The pre-feasible profiles for the promotion of LC required the identification of a set of products and services which use LC. This identification was based on the analysis of the activity sectors of the companies which are located in a LC within the Central Region, and the analysis of a list of companies which are located in Logistical Platforms and LC in Europe (see [2]).

In order to assure the success of a LC, a portfolio of clients must be promoted. Such clients must have homogeneous logistics requirements. The following criteria must be considered in the choice of the portfolio: goods compatibility, capillarity of the physical distribution, complexity of the orders processing, re-order characteristics, and logistics performance requirements of the several commercialization channels.

The products and services previously presented (opportunity niches) and the mentioned criteria, specially the logistics homogeneity, were the base for the construction of the following profiles for the development of LCs [10]:

a) Footwear (men, women fashion, children, and sport); processing centres for logistics operators whose speciality is fashion casual clothes sold to sell points chains; underwear; costumes.
b) Spare parts for cars; hardware store products; plumbing items; furniture and linings for bathrooms and kitchens; electrical material.
c) Pharmaceutical products; items for hospitals; cosmetics and beauty products.
d) Food for pets; items for cleaning; groceries.
e) Printing and stationery products; products for offices; disks and dvds distributors; books and publishing.
f) Distributors of carpets and mats; distributors of cloth.
g) Furniture; domestic small tackles; appliance.
h) Computer equipment; telephone items.
i) Paintings; waterproof products, adhesives, resins and other chemical products.
j) Goods reception centre for chains belonging to supermarkets and department stores; distribution centres for restaurants or coffee shops franchises; suppliers for hotels and restaurants; wine and liquor distributors; distributors of natural, dietary and ethnic food; milky products; frozen products.

Also, it is convenient to include to each profile, the following: terminals for line-haul freight transportation companies, terminals for urban freight transportation companies, terminals for industrial packing logistics operators, facilities for freight agents (for consolidation/un consolidation, inspection, etc), parking for trailers.

In certain cases, it is necessary to integrate additional complementary services (spare parts shop, hotel, business centre, etc).

4.4. Strategic proposals for integrating a portfolio of LC projects in the Central Region

Two types of strategic proposals for integrating a portfolio of LC projects in the Central Region are presented. One proposal is linked to the goods "megapolitan" distribution for specific industrial sectors; the other one is for the modernization of the transportation services operation towards an integral logistics services offer. The objective of both of them is the innovation and improvement of the logistics competitiveness.

The first proposal is focused on the industrial sectors where it is necessary to change the distribution pattern for the goods producer companies, in order to guarantee the competitiveness and extend the market size reducing logistics costs. The projects which must be promoted are described below (anyone requires a previous marketing study).

Project 1: A LTSC for the footwear industry, produced in Guanajuato and sold in the Central Region, considering the different segments (men, fashion for women, children, school and sport); such LTSC must be located near the intersections of the México-Querétaro highway and the Arco-Norte highway and the Vialidad-Mexiquense highway (see SLNs in the north-western part of Figure 6).

Project 2: A LTSC or a CLP focused on the distribution of hardware store products, plumbing items, furniture and linings for bathrooms and kitchens, and electrical material. It must be located near the intersection of the México-Querétaro highway and the Arco-Norte highway or the intersection of the México-Querétaro highway and the Vialidad-Mexiquense highway (see SLNs in the north-western part of Figure 6).

Project 3: A LTSC for hotel and restaurant suppliers, distribution centres for restaurant or coffee-shop franchises, and distributors of natural, dietary and ethnic food. It must be located in the SLN of the Puebla-Tlaxcala metropolitan zone, or/and the Toluca Metropolitan zone or/and the Cuernavaca Metropolitan zone (in Figure 6, these SLNs are respectively located in the south-eastern part, the western part and the southern part).

Project 4: A ULMP focused on the clothes industry, in the Historical Centre of Mexico City.

Project 5: A LTSC focused on the CD and DVD industry and the editorial industry. It must be located within the MZMC, in the western area (San Antonio-Observatorio).

The second proposal is focused on modernizing the production of transportation and logistics services towards an integral offer of logistics services.

A set of IMC must be sowed in strategic locations of the Central Region, as in the identified SLN, in order to solve the connection problems between the line-haul transportation operations and the physical distribution in urban areas. Without a set of IMC in the surroundings of the main cities of the Central Region, it is impossible the innovation of the logistics distribution towards a centralized operation, and the reduction of congestion and emissions produced by freight trucks.

There are not SLN within the Federal District (there are not available and suitable plots), and the government of this state is not involved in a strategy for the promotion of IMC in the other states of the Central Region. While this situation continues, the restrictions for freight trucks within the Federal District are not feasible.

Several considerations must be taken for the promotion of LC in the Central Region. A description of them is presented by Antún et al. [2, 3].

4.5. Basic modules for the integration of different types of IMCs

The complexity of a LC project depends on the level of integration of a subset of types of LC, where each one is considered as a business unit.

The several IMC suitable for the market needs in the Central Region can be integrated by means of using basic modules which require available plots of 30-60 hectares. Some basic modules are presented by Antún et al. [2, 3].

5. CONCLUSIONS

The paper presents a methodology for the implementation of IMC projects in SLNs, which is applied to the Central Region of Mexico.

Some interesting results of the analysis of the AADT of trucks are the following:

a) Nearly 5% of total flow corresponds to trucks.
b) The segments with the highest AADTT are located around Mexico City.
c) The roads with bottlenecks segments for trucks are the following: the México-Toluca highway, the Barrientos-Ecatepec freeway, the Naucalpan-Toluca highways, the México-Querétaro highway and the Los Reyes-Zacatepec freeway.
d) It is necessary improve the road segments which form bottlenecks, specially on the Tlalnepantla- San Gabriel and the Los Reyes – Zacatepec freeways.
e) It is important to improve urban corridors within the MZMC, especially those forming arcs of rings or connecting industrial areas.

The analysis allowed indentify opportunity niches in industrial and services sectors which are important for the development of LC projects in the Central Region, and the best places for LC location.

A set of SLN for locating LC were identified for the Central Region. Most of them are located near the intersections of the Arco-Norte highway and other important highways on the northern part of the MZMC.

In order to assure a sustained success for LC projects, specifically IMC projects, a portfolio of clients must be promoted; the clients of this portfolio must have homogeneous logistical requirements, based on five mentioned criteria. The criteria and the identification of products and services in LC were the base for the identification of pre-feasible profiles for the development of LC in the Central Region. A set of five pre-feasible profiles were presented (four LTCS and one ULMP). Also, the implementation of several IMCs in the identified SLNs of the Central Region was recommended.

The main benefit from the implementation of the set of IMCs is the logistical territorial management, which is very important for the cities of developing countries, where the land-use planning is deficient.

REFERENCES

1. Antún, JP; Lozano, A; Hernández, R; Alarcón, R; Muñoz, MA (2008a) Centros Logísticos, SD-50, Series del Instituto de Ingeniería, April, México DF, 185 p. In Spanish.

2. Antún, JP; Lozano, A; Alarcón, R; Granados F, Guarneros, L. et al (2009) Estrategias para el Ordenamiento Territorial Logístico competitivo de la Central Region, Convenio de investigación con la Secretaría de Economía del Gobierno Federal de México, Fondo PROLOGYCA y Fideicomiso para el Desarrollo de la Central Region País (FIDCENTRO), Instituto de Ingeniería, Universidad Nacional Autónoma de México, México DF. In Spanish.
3. Antún J.P., Lozano A., Alarcón R., Granados F., Guarneros L. (2010) The physical distribution of goods in a megalopolis: strategies for policies on the location of logistical facilities within the Central Region of Mexico. Procedia Social and Behavioral Sciences 2 (2010) 6130–6140. ISSN 1877-0428. Science Publications, Elsevier.
4. Lozano, A., Antún J.P., Granados F., Alarcón R., Magallanes R., Guzmán A. et al., (2006) Estudio integral metropolitano de transporte de carga y medio ambiente para el Valle de México. Convenio de investigación con la Comisión Ambiental Metropolitana, Instituto de Ingeniería, Universidad Nacional Autónoma de México, México DF. In Spanish.
5. Lozano A., Antún JP., Santos C., Alarcón R., Guzmán A. & Hernández, R (2008a) Propuestas de Centros Logísticos para el Valle de México, SD-51, Series del Instituto de Ingeniería, Julio, México DF, 119 p. In Spanish.
6. Lozano, A; Antún, JP; Granados, F; Santos, C (2008b) Reserve areas for logistics activities in the Metropolitan Zone of Mexico City. En Innovations in City Logistics (E. Taniguchi and. R.G. Thomson eds.). Nova Science. ISBN: 978-1-60456-725-0. Pp 321-334.
7. Antún J.P., A. Lozano, R. Hernández, R. Alarcón (2008b) New trends on distribution in the Metropolitan Zone of Mexico City. En Innovations in City Logistics (E. Taniguchi and. R.G. Thomson eds.). Nova Science. ISBN: 978-1-60456-725-0. Pp. 517-530.
8. Lozano A., JP. Antún, C. Santos, R. Alarcón, F. Granados, R. Hernández (2006) Bases for a policy for the development of logistics platforms in the metropolitan zone of Mexico City. En Recent Advances in City Logistics (E. Taniguchi and. R.G. Thomson eds.). Elsevier, ISBN: 0-08-044799-6, 554 pages.
9. DGST-SCT, (2008). Libro de Datos Viales 2008. Dirección General de Servicios Técnicos, Subsecretaría de Infraestructura, Secretaría de Comunicaciones y Transportes (SCT), México 2008.
10. Antún, JP; Hernández, R; Alarcón, R; Lozano, A (2009) “Estrategias para políticas y prácticas sustentables en transporte metropolitano de distribución de mercancías”, Memorias del XV Congreso Latinoamericano de Transporte Público Urbano (XVI CLATPU), Buenos Aires (Argentina), Marzo 31-Abril 3, 2009. In Spanish.