ELSEVIER
www.elsevier.com/locate/cities

doi:10.1016/j.cities.2004.10.003

Cities, Vol. 22, No. 1, p. 15–28, 2005
© 2004 Elsevier Ltd.
All rights reserved.
Printed in Great Britain
0264-2751/$ - see front matter

Solutions applicable by local administrations for urban logistics improvement

Jesús Muñuzuri*, Juan Larrañeta, Luis Onieva, Pablo Cortés

Organization Engineering Group, School of Engineering, University of Seville, Camino de los Descubrimientos s/n, 41092 Seville, Spain

This paper aims to establish a compilation of the solutions or initiatives that can be implemented by local administrations in order to improve freight deliveries in urban environments. These improvements are not defined from the point of view of logistic companies, but from the point of view of urban communities and the relation between freight transport and general urban traffic. All the solutions considered here are generic, that is, suitable a priori for any given urban area, although their degree of appropriateness and expected results will depend on the specific characteristics of the city. Solutions are classified into those related to public infrastructure, land use management, access conditions, traffic management, enforcement and promotion.
© 2004 Elsevier Ltd. All rights reserved.

Keywords: City logistics; freight transport; urban areas; local administration

Introduction

Despite the relevance of freight movements in the support of economic life in urban areas, it is often found that urban logistic operations play a secondary role in city planning priorities. Much more attention is paid to freight transport on an interurban level, due to the evolution of supply chain analysis, but this attention is basically devoted to cost factors, which are to be minimized in order to improve the efficiency of the system. However, within the city there are other intangible factors which constrain freight transport and deliveries. Urban logistics has been defined as those movements of goods that are affected by particularities associated to urban traffic and morphology (Sustainable distribution, 1999). These factors are basically caused by the clash of interests between urban freight carriers and other stakeholders involved in urban traffic (Robusté, 1999), like passenger car drivers, buses, residents, pedestrians, etc. The conflicting needs for fluid displacements, parking spaces, environmental conditions, etc. (Kitada, 1992), and the usual coincidence of peak hours (Thoma, 1995), constitute a permanent source for inefficiencies and the need for short, medium and long-term planning. Besides, the increasing demand for all types of mobility in medium–large cities aggravates this clash, especially in the case of European cities, where historical city centers are usually not able to absorb the high levels of demand for passenger and freight transport.

The solutions outlined here are tools available for local administrations for better planning and performance of city logistics systems. City logistics is the term used to denote the specific logistic concepts and practices involved in deliveries in congested urban areas, the ''last mile'' transport, with specific problems such as delays caused by congestion, lack of parking spaces, close interaction with other road users, etc. It is defined as ''the process for totally optimizing the logistics and transport activities by private companies in urban areas while considering the traffic environment, the traffic congestion and energy consumption within the framework of a market economy.'' (Taniguchi et al., 2001). It concentrates mainly on goods transport, although Allen states that urban logistics analyses should also

*Corresponding author. Fax: 34 954 487 329; e-mail: munuzuri@esi.us.es

include service vehicles (inspections, installations, technical service, and emergencies) and other commercial uses (sales representatives, company cars: Allen et al., 2000). In any case, the use of these solutions to deal with urban logistics issues does not necessarily mean bigger benefits for logistic companies, but rather an attempt to better regulate and manage freight deliveries in urban areas. The ultimate objective is the reduction of the clash between the interests of logistic companies and those of other stakeholder groups involved in urban mobility.

Types of solutions for urban freight transport

Specific and combined solutions

It is important to distinguish between two levels of measures related to urban logistics. Specific solutions are those addressed to specific problems or requisites. They are chosen for implementation according to the requirements of the groups of stakeholders in the city, and they can therefore have a positive effect on some of these groups and a negative one on others. Only specific solutions will be dealt with here. On the other hand, combined solutions are generated by the combination of several specific solutions, and they constitute a strategic policy for logistics in the city. Whereas specific solutions may benefit only one or some of the groups of stakeholders, combined solutions should induce a benefit as evenly as possible for all groups, without any of them being clearly damaged in its interests.

It is important to stress that radical opposition by any of the stakeholders' groups to the logistic policy reflected by the combined solution may be sufficient for the disregarding of the project. Besides, when designing a combined solution, by adding several specific solutions, two starting points must be contemplated, since the fact of their being evident does not reduce their relevance:

- The specific solutions combined must be compatible, that is, they must not either exclude each other or be redundant.
- The effect of the combined solution on the groups of stakeholders will most likely be different to the sum of all the individual effects caused by each specific solution.

Types of specific solutions according to their scope

Urban freight solutions can be divided into five groups, depending on their field of application:

- *Solutions related to public infrastructure*. These correspond to the building of new infrastructures or adaptation of existing ones to serve as transfer facilities for city logistics purposes. Also, the modal shift of urban freight movements typically from road to rail is contemplated here.
- *Solutions related to land use management*. These refer to the allocation of land to be used for city logistics operations. Initially, different possibilities for providing parking spaces or delivery operations are described. Besides, local authorities may issue different regulations affecting new or existing buildings in congested areas of the city in order to facilitate the delivery of goods.
- *Solutions related to access conditions*. Two types of restrictions are included here. On one hand, spatial restrictions, which impose limits on the entry and displacements of delivery vehicles in the affected area. On the other hand, time restrictions, which limit the periods during which these vehicles may enter the area or use the existing infrastructures.
- *Solutions related to traffic management*. These solutions are aimed at reorganizing the flows of delivery vehicles in the congested areas of the city. Measures regarding the scope of regulations are not specific solutions themselves, but refer to the way in which other solutions affect the different carriers and city areas. Also considered here are the application of information technologies for city logistics improvement, and the application of cooperation schemes.
- *Solutions related to enforcement and promotion*. Again, this category is intended to work together with the previous ones within combined solutions, representing possibilities of implementation. Promotion tools can be used by the local administration to support certain practices without imposing them, whereas enforcement tools ensure the compulsory application of other specific solutions.

Types of specific solutions according to the implementing group of stakeholders

City logistics solutions can be classified depending on the group of stakeholders that would be responsible for their implementation. Thus, there are solutions implemented by:

- *Carriers/logistic operators*. Companies delivering goods to destinations inside the city.
- *Receivers*. Companies (usually local businesses or commercial premises) that receive goods delivered by carriers.
- *Local authorities*. Responsible for establishing regulations regarding traffic and transport in the city.

The compilation presented here concentrates on regulatory and policy aspects regarding urban logistics, and thus it includes only those solutions applicable by the local administration. Nevertheless, the implication of national governments may be crucial at the beginning of the planning process

in order to guarantee an adequate legislative environment, and in the end it is always private transport companies who have to adapt themselves to the new scenarios (Visser et al., 1999). Readers interested in commercial solutions applicable by companies (carriers or receivers) may refer to (LEAN, 1999).

Several more groups of stakeholders related to urban logistics may be identified (Robusté, 1999), but only the three previously mentioned groups have the capability for this type of implementation. In the case of the other groups (residents, urban planners, etc.), their interests can be assumed to be represented by the local authorities.

Glossary of solutions applicable by local administrations

Table 1 contains all the different specific solutions that will be briefly described in the rest of the paper. In the cases when a specific solution has been tested or fully implemented in a city, the corresponding reference (or at least one of them, in cases where many cities have tried it) will be given.

Solutions related to public infrastructure

City terminals

A city terminal is a small freight transport center located inside the urban area. It is usually based on only one mode of transport (road transport), and is intended to improve load factors in delivery vehicles, since the city terminal can be accessed by larger trucks, and the goods are then transferred to smaller vans for their final delivery, which now have to cover smaller distances (Thoma, 1995). Parking lots located near congested commercial areas of the city are usually used as city terminals, with easy access from ring roads, space for vans and trucks, and possibly transshipment devices and warehousing capabilities (Tellus-Berlin, 2004). The main drawback of this configuration is the introduction of a new transshipment in the logistic chain, with all the costs and delays involved (Bestufs, 2002), but perhaps a new logistic system, oriented towards making extensive use of these terminals, might improve traffic and freight delivery in the city. General guidelines for the implementation of a city terminal are given in Dablanc et al. (2002).

Table 1 Classification of urban freight solutions for application by the local administration

Local administration solutions for urban freight		
Public infrastructure	Transfer points	City terminals Outskirts logistic centers Logistic improvement of terminals Use of rail or ship terminals Use of public parking lots
	Modal shift	Use of the train or underground system Shuttle train
Land use management	Parking	Load zone provision Parking space planning Hub areas Use of other reserved spaces
	Building regulations	Load/unload interfaces Use of private parking lots Mini-warehouse
Access conditions	Spatial restrictions	Access according to weight and volume Access to pedestrain zones Street blocking allowance Closing the center to private traffic Road pricing
	Time restrictions	Adequate rotation in load zones Night deliveries Double-parking short time restrictions Access time windows
Traffic management	Scope of regulations	Carrier classification Freight zone classification Harmonization of regulations Street classification
	Information	On-line load zone reservations

Outskirts logistic centers

This type of centers play a role mostly in interurban transport, but they may also be considered as part of the urban logistic chain, with the aim of minimizing costs or maximizing levels of service. The promotion policies aimed at concentrating companies involved in urban deliveries in these centers sets the grounds for innovative schemes like:

- Cooperation between companies for load consolidation.
- Feasibility of alternative modes (rail, tram) for goods transport for the logistic center to the city terminals.
- Conjoint use of telematic tools.
- Transshipment directly from trains to delivery vans.

Several experiences in the development and improvement of these logistic centers were combined in the FREIA project (FREIA, 1998).

Logistic improvement of terminals

This measure is related to enhancing the concentration of carriers in the existing terminals in the city, in order to seek the conjoint exploitation of infrastructure and technologies (telematics, routing software, etc.). The regulation of this conjoint use (that is, the degree to which each company would be allowed to use the resources), may be determined in different ways:

- According to the investment made by each company within the total investment, in case this investment was made by the companies themselves.
- According to the sizes of the companies, in case the resources were provided by the administration to the companies.
- According to the rate paid by each company, in case the use of the resources provided the companies with clear added value.

This type of experience may be represented by the Eurogate initiative in Spain.

Use of rail or ship terminals

In case the distance between these areas to the center of the city is not too large, their use as urban freight facilities has several different possibilities:

- The use of this land as a city terminal, independently of the goods having arrived on a train or boat or not. The existence of available space in the grounds of the station or the port, together with their usually good location within the city, often supports this use as a city terminal.
- The possibility of receiving or sending goods on trains from intermodal freight terminals, thus becoming part of a regional, national or international intermodal network.
- The use of the station or port as a transshipment point between long distance rail freight transport and final urban deliveries.

Use of public parking lots

Public parking lots are used mainly for passenger vehicles on a rotating basis. However, these spaces are in many cases perfectly suitable for taking logistic operations away from the curbside, especially in cases where the parking lot is located in dense commercial areas. Land use regulations may be used to force these parking operators to reserve a fraction of their space for load/unload operations, and the goods would then be carried on foot to their destination. This is an easier solution to implement in the case of parking lots under construction or in the planning process, since the access of vans and the ways of getting the goods again on street level are important aspects which can be addressed beforehand. For existing parking lots, only small vans and low-size items would be appropriate.

Use of the tram or underground system

The intention here is to use these transport modes, usually only applied for passenger transport, to freight delivery processes. The idea would be to use dedicated trains, or cars included in passenger trains, to carry goods. It seems unfeasible to use this system for general freight transport (Van Duin, 2002), but it may be used in reduced scenarios. A feasible use would contemplate this system applied to goods that require urgent movements, or that present a sufficiently continuous flow as to benefit by these high capacity modes (Huschebeck, 2002), keeping in mind that this feasibility requires the achievement of economies of scale in order to pay for the extra transshipments. The use of these modes also benefits the environment in the city, as well as congestion levels. However, the need for specially designed boxcars and load/unload equipment, as well as the adaptation of infrastructures, require important investments to be made.

Shuttle train

This type of train would be used, in case of high volumes, for freight transport between outskirts logistics centers and between these and city terminals, located within dense urban areas, for their final delivery. The lines would be the same ones used for passenger transport, but the trains would probably require being dedicated, due to the slow load/unload speed of goods when compared to passengers. The main requirement for the implementation of this solution is the conjoint use of the system by a significant number of carriers, in order to attain large quantities of goods so as to

make such a transport mode economically feasible. The cost of infrastructure adaptation is also the main drawback of this solution. On the other hand, the reduction in congestion and pollution caused by trucks entering the city would be significant enough to justify a deeper analysis.

Solutions related to land use management

Load zone provision

The allocation of curbside parking spaces to serve as load zones (reserved spaces to be used by delivery vehicles for loading or unloading freight in dense urban areas) is nowadays a widespread policy, present in most cities around the world. However, the lack of space and the increasing need for deliveries in dense urban zones make it desirable to find other spaces for delivery vehicle parking. Building regulations can be used to reorganize parking spaces, and thus have a direct effect upon urban freight delivery operations. This solution refers to the introduction in building regulations of the need for load zones to be located inside the building, in order to take load/unload activities out of the curb space. Previous analyses should be carried out in order to determine the number and size of load zones required in each case, depending on the size of the building and the type of activity to be located in it (Wegmann et al., 1995). If the building surface reaches a certain extension, the load/unload facilities should be located underground, otherwise, they may be located elsewhere. Clauses should also be included with relation to the use of those facilities, regarding environmental aspects such as noise, pollution, etc.

Parking space planning

This solution seeks to reduce the number of parking spaces in a certain urban area, by eliminating curbside parking places without building any parking lots. Apparently contrary to economic development, it is a solution suitable for very congested areas, where pollution and double parking constitute a severe problem. It is oriented to improving general traffic conditions rather than urban logistics itself, but this reorganization implies a reduction in the congestion levels in the area, which improves the freight delivery scenario. Since it is a controversial solution from the political point of view, its introduction should work best when combined with the provision of alternatives for the drivers of private passenger cars, like the opening of parking lots in the surroundings of the area or improvements in the public transport system, like the opening of a new metro line. This counterbalance allows for the introduction of measures that would otherwise generate strong opposition from several groups of urban stakeholders.

Hub areas

This solution proposes the introduction, in the congested downtown area of a city, of a number of areas consisting of reserved parking spaces for vans and trucks, where the vehicles would stay parked while all the deliveries for the area are made on foot or by using a handcart or some alternative vehicle. These hub areas may substitute normal load zones, perhaps in a scenario where there are access time windows, with the idea of not having freight delivery vehicles moving along congested areas at certain times. Delivery times would then increase substantially, but so too would the reliability of those delivery times and the hours during which deliveries might be made. The entry and exit routes to these hubs would have to be defined, and it is also necessary to ensure the adequate rotation of freight vehicles in the hubs. The solution is also very much improved when applied in combination with cooperation schemes between carriers, since then the number of freight vehicles to be allocated in the hubs is strongly reduced. However, this solution is only feasible when the type and quantity of goods to be delivered allows the distance between the hub and the final destination to be covered within reasonable time and effort.

Use of other reserved spaces

Four types of reserved spaces are contemplated here, and the proposal is to allow freight delivery vehicles to share their use, either on a time basis (during a certain time interval) or on a space availability basis (when there is enough space available not being used for its original purpose):

- Taxi zones are usually located near commercial areas in the city, which makes them suitable for load/unload operations.
- Bus lanes (Barcelona City Council, 2003) can be used for driving or for curbside parking of freight vehicles in certain urban areas and during certain time intervals, since the peak periods for bus demand are different from those for freight delivery demand.
- Motorcycle parking spaces are very useful in those cities where motorcycles are a major transportation mode, but these spaces are usually empty at certain times of the day, and they could be used then as load zones.
- Parking spaces for disabled people, though necessary, are often empty, and could be used for load/unload operations during short periods of time in very congested areas where the space availability is scarce.

Load/unload interfaces

One of the main causes behind the problems faced by city logistics is the lack of specific infrastructure

to facilitate the access and parking of vehicles, the loading and unloading and the delivery of goods. Land use regulations may contemplate, in the case of buildings with commercial premises on the ground floor likely to act as freight receivers, the need for special logistic facilities. An access for goods deliveries different from the one used by customers allows the carrier to unload goods without disturbing the normal activity in the shop. Also, in-house parking places for delivery vehicles avoids the need to use curbside space in order to unload goods.

Use of private parking lots

Many residential buildings have their own parking lots, either underground or in the open. Many of the spaces in these lots are empty during the day, and may be used by freight delivery vehicles when doing home deliveries, lasting for more than 15–20 min, so that it would not be necessary to block the street in the meantime. The size of the delivery vehicles would need to be reduced enough in order to enter these parking lots, designed exclusively for passenger cars. Delivery times would presumably increase, but double parking in front of these buildings would be eliminated, or at least significantly reduced.

Mini-warehouses

The possibility of delivering goods without the receiver being present is an interesting concept in the sense that it releases the carrier from delivery time constraints and allows better planning of city logistic operations. This proposal consists of setting up small groups of lockers for goods arriving to a dense and congested area of the city. The use of these lockers would allow freight delivery vehicles to make a single short stop at the lockers instead of one stop for every receiver, and could be suitable for night deliveries. Issues related to final deliveries to the receivers, responsibility in case of loss or damage of the goods and security problems need to be discussed before proceeding to implementing this solution. Different kinds of applications are possible, ranging from completely independent structures like mailboxes on the streets, to the option where the facility is integrated within a building. Depending on the kind of goods to be delivered, the mini-warehouse may have either a vertical or a horizontal structure. Also, for large concentrations of mini-warehouses, it could be necessary to add other services like security. These facilities are being used by logistic companies for home deliveries in the Netherlands.

Solutions related to access conditions

Access according to weight and volume: The proposal here is to establish criteria to determine the type of vehicles that are allowed to access each zone of the city. These criteria are usually linked to the weight of the vehicles, but sometimes size (Certu, 2002) or the load factor of vehicles (Municipality of Copenhagen (2003)) is directly used as an access criterion. This type of measure is initially aimed at avoiding traffic problems, by allowing access only to vehicles with an adequate size for the streets of the city. However, it also improves the livability of the city, reducing environmental impacts for instance, and can also indirectly promote intermodality, since it forces an additional transshipment outside of the city from large-size, long-distance vehicles to smaller ones, suitable for final deliveries.

Access to pedestrian zones

These areas represent one of the most controversial tools used to limit the mobility of passenger cars in the downtown area of cities. The desirable effect of achieving a more pedestrian–friendly city is opposed with the danger of diminishing the accessibility of persons and goods to the city center, with its subsequent degradation. Within the scenario of city logistics, it is necessary to allow, under certain conditions, the access of freight delivery vehicles to pedestrian areas. Several possibilities are available, for selection of a single one or in combination:

- Free access during the night of all types of vehicles, including those used for freight deliveries, to pedestrian areas.
- Restricted access for freight delivery vehicles during the time interval allowed by the access time windows.
- Use of special vehicles (e.g., electric, silent) in order to access pedestrian zones during commercial hours.
- Determination of the types of goods whose vehicles are allowed to enter the pedestrian area.

An example of this type of policy can be found in Melbourne (City of Melbourne, 2004).

Street blocking allowance

In many cities with narrow downtown streets, a special regulation is required to take into account situations that take place on a daily basis. In case there are streets with a single lane in a single direction, most load/unload operations carried out in that street will imply the blocking of traffic. Therefore, if the provision of load zones is not possible on those streets, regulations may allow freight vehicles to block narrow streets for loading operations, thus showing more consideration for a practice that is in many cases being performed illegally. This could only be done for a limited time length, for specific types of deliveries, and the specific streets where this could be done would have

to be determined beforehand, and perhaps signaled. Carriers might be forced to place a signal at the beginning of the street, warning about the temporary blocking, causing delivery times to increase, but reducing the hassle for other drivers.

Closing the center to private traffic

A typically controversial solution, the restriction of access for passenger cars, whether totally or by means of access time windows, is in many cases the only tool available to preserve this area free of congestion and environmental damage, and is usually associated with the definition of selective pedestrian areas. The central area remains closed to all vehicles but public transit, resident vehicles and freight vehicles during business hours. The implications of this solution with respect to passenger cars are sufficiently analyzed (Sta spa, 2002), but the question here is how to achieve a better freight distribution in the restricted area.

Enabling access for freight delivery vehicles, the availability of parking spaces and the absence of congestion should allow easier and more reliable deliveries. An example of this type of policy can be found in Granada City Council (1997) and Gloucester City Council (2004).

Road pricing

The policy for charging vehicles for entering certain areas of the city, typically those where road and parking space are scarce, is the most direct way of internalizing the external costs originated by traffic congestion. The main effect sought with the implementation of this solution is a reduction in the number of vehicles entering congested areas of the city, ideally with a reallocation of mobility towards public transport. However, there is also the raising of revenues that would normally be used for improving public transport systems. The implications of this type of scheme regarding general passenger traffic are widely analyzed for the historical case of Singapore (Button and Pearman, 1985), but with respect to freight transport, several additional issues deserve to be mentioned:

- It introduces comparative disadvantages in the charged area, which might result in a reduction of its attractiveness and, in the long run, the subsequent relocation of commercial premises in other areas of the city.
- The generalized introduction of this additional tax implies the raising of prices and thus an increase in inflation levels.
- The usually inelastic demand of freight deliveries and the low margins assumed by the transportation industry might result in the infeasibility of these deliveries, unless trucks pay a significantly lower price than passenger cars. Although journey times and uncertainty are reduced, these reductions do not often have a significant impact on the carrier's cost figures.

The most up-to-date example of this policy, and one observed with expectation by many other cities as a radical tool for congestion reduction, is the London example (Transport for London, 2003).

Adequate rotation in load zones

This solution seeks to take steps towards a better use of load zones by freight carriers. The aim is to avoid excessively long stays in the zone, thus guaranteeing that the use of the resource (the load zone) is as close to optimal as possible. The idea is then to limit the amount of time during which delivery vehicles may be parked in load zones without moving. This amount of time, typically defined depending on the distance between the load zone and the final delivery points, would be around 15–30 min. Special surveillance would then be required, in order to ensure that this regulation is fulfilled.

Night deliveries

By delivering goods during the night, it is possible to avoid interference with peak hour congestion. Since it does not seem feasible to change that passenger car peak hour, it might be possible to take freight deliveries out of it. However, the main opposition to this solution comes from residents due to noise pollution, thus silent vehicles are required, as well as being careful while performing load/unload operations, since in many cases the source of disturbance is the staff behavior, doors closing, voices, etc. Besides, this solution seems only useful for large carriers or companies that carry their own goods, since delivery times can be easily agreed within the company. In case of less-than-truckload transport or deliveries to small retailers, the receiver must be present when the delivery is made, and therefore they are not always willing to accept night deliveries (Watson, 2002).

Double-parking short time restrictions

In many cases, the total suppression of double parking should not be an objective, due to the amount of load zones required, the restrictions to the movement of vehicles and the surveillance requirements. Instead, double parking should be allowed for load/unload operations in streets with more than one lane in each direction (so that through traffic is not completely blocked), and with no reserved load zone nearby, for a limited time period. Double parking is a very much extended problem in many cities, and its complete eradication would undermine economic development. Thus the proposal is to create reasonably

restrictive regulations to deal with it, so that double parking for delivery operations would be allowed in certain streets during intervals not longer than 15 min. The purpose is not, therefore, to reduce the problem of double parking in the downtown area, but to normalize a situation that nowadays seems unavoidable, unless other valid alternatives are provided.

Access time windows

The establishment of time intervals exclusively during which freight delivery vehicles are allowed to enter certain parts of the city (normally dense central areas) are one of the most common policies to manage urban freight access (City of Glasgow, 2001; Tellus-Rotterdam, 2004). These time windows usually cover from the early morning hours up to the middle of the morning business hours, with maybe another period in the afternoon. The objective of the time windows is assumed to be the avoidance of the collision of interests between different groups of stakeholders, namely freight carriers and the owners of cars who drive them to work or go shopping in the restricted areas. However, there are usually some negative side effects that are often not assessed prior to implementing this solution. The fact is that very often, due to access time windows, freight delivery vehicles are forced to enter congested areas during peak hours, thus worsening congestion and pollution problems. Therefore, when attempting to implement this solution, careful analyses and evaluation processes are required beforehand, to ensure that the negative effects do not outweigh the positive ones (LEAN, 1999).

Solutions related to traffic management

Carrier classification

It is often found that regulations regarding freight deliveries in urban areas affect equally to all types of carriers. However, different types of carriers usually present different delivery times, a different number of deliveries, different duration of those deliveries, etc. Thus, in a more efficient planning scenario, different types of regulations should be applied to them. Some of the classifications to be made could include:

- *Full truckload carriers (high load factors) or less-than-truckload carriers (low load factors)*. Longer use of load zones may be allowed for the former, which is compensated by a more efficient use of their vehicles.
- *One delivery per vehicle (deliveries to supermarkets or specialized stores) or multiple deliveries (press deliveries, beverages to bars)*. Different time windows may be considered, as single-delivery vehicles spend less time driving and more loading and unloading than multiple-delivery vehicles.
- *High-weight items (furniture) or low-weight items*. Different accessibility regulations (for example, to pedestrian or very congested zones) may be distinguished.
- *Deliveries to small premises (normally not suitable for night deliveries) or to large premises (suitable for shifting to night deliveries)*. The latter may be suitable for promotion of night deliveries.

Freight zone classification

It is very often found that the same approaches regarding freight transport are applied in the whole of a city, perhaps with a limited sector of the downtown area being given a specific consideration. However, different areas of the city have different economic patterns, and thus different freight transport needs, and should therefore be treated differently. In order to better manage urban traffic in the city, it is previously necessary to define different freight zones, with homogeneous freight distribution patterns, that should be contemplated specifically. For example, residential areas, commercial areas and tourist areas are often affected by different types of problems. This does not mean that there should be different regulations for freight transport in these zones, since homogeneous regulations should always be an objective. Instead, this classification should be useful for identifying problem areas, and then implementing the appropriate urban freight solutions for each one, like assigning police control, planning infrastructures, etc.

Harmonization of regulations

It is often found that cities apply logistic initiatives independently, that is, a certain carrier operating in several cities within the same country may find different accessibility regulations, access time windows, type of terminals, or even signaling. Although the specific scenarios found in different cities require different types of solutions, it seems desirable to unify policies, especially from the point of view of nationwide logistic operators. Inter-city institutions promoted from the national government, such as the GART (Groupe d'Autorités Responsables de Transport) in France, are needed for this type of harmonization.

Street classification

There are different ways to classify the streets in a city, but this classification is made according to freight delivery issues. The criteria used for this classification can be street width, traffic conditions, proximity to commercial or business areas, parking availability, etc. This classification can then be used to establish measures related to issues such as parking space planning, traffic light regulation, police control, load zone provision.

- *Access streets*. Freight vehicles use them to enter or leave the downtown area or other commercially dense areas.
- *Restricted access streets*. Only allowed for certain transport modes (taxis, buses, freight transport, residents).
- *Load/unload streets*. Where load/unload operations can be carried out, maybe because there are load zones located in them or maybe because double parking is allowed for delivery operations.
- *Non-freight streets*. Load/unload operations are not allowed because the street is too narrow, double parking is not permitted, etc.
- *Pedestrian streets*. Both access and load/unload operations are banned.

On-line load zone reservations

It is often found by truck drivers on delivery tours that, on arriving to a certain load zone, it has been previously occupied by another freight delivery vehicle, forcing the second truck to circle around or double park with the risk of being fined. A possible way to improve freight transport efficiency is then to allow freight carriers to reserve load zones, thus ensuring their availability at the requested time and improving the reliability of deliveries. The rotation of vehicles in load zones is also promoted, because of the limited time slots guaranteed by reservations. The system requires a central station for data processing and reception of reservations, via telephone or the Internet, as well as on-site equipment for reservation control and display. Two issues are relevant to this type of solution:

- Strict surveillance is required for ensuring that vehicles limit their operations to fit their reserved time slots. Automatic identification systems or parking meters might be suitable for this purpose.
- Reservations should be charged with a small price, sufficient for covering the costs of the service.

A pilot test for this type of solution is described in (Agostini et al., 2003).

Real time traffic information

The base for any type of real time fleet management is the availability of updated information about the traffic scenario. This information can be generated by the local administration from traffic counters located on the streets, as well as statistical processing of the collected data, since a very low flow of vehicles might mean a very low traffic density but also a very high level of congestion. Then the processed real time information would be made available, free or by payment, via the Internet, to freight transport companies and also to all kinds of vehicles. The availability of such a system in a city would open the door to the introduction of real time traffic management systems, not only related to freight transport, but also to traffic light coordination, accident management, etc (Taniguchi et al., 2001). This would result in the optimization of the street network, and indirectly in economic benefits and an increase in the livability of the city. Although routing tools based on real-time data are currently not operating in any city, an interesting initiative for informing drivers of real-time congestion via the Internet is currently running in Houston.

Freight carrier cooperation

One of the most typical characteristics of carriers and logistic operators is their independence within a very competitive environment. Larger load factors, economies of scale and cost reductions might be achieved through cooperation between competing carriers, but their individual presence in front of their clients seems to be a more important asset. Public promotion of this cooperation might lead to a significant reduction in the number of freight vehicles, with the consequent benefits for traffic and the environment in the area. The idea is to have a single carrier (the common carrier) that makes a collection round of all the goods to be transported by different carriers, and then delivers them at their final destinations. This cooperation might be materialized in different ways, in order to respect the status quo of the different transport companies: a time-sharing scheme, where the common carrier task is performed by all carriers in turns, perhaps one every day or week; or an area-sharing scheme, where every carrier is assigned to a specific area of the city to act there as common carrier for all the companies (areas might also rotate in turns). This solution works best when all the carriers involved in the cooperation scheme are located at the same logistic terminal, or at least close to each other. Examples of pilot tests with type of scheme can be found in Freiburg (Thoma, 1994) and Kassel (Strauss, 1995), although their effectiveness is very much dependent on the amount of cooperating companies, since feasibility is only achievable by means of strong economies of scale.

Joint deliveries

This solution appears as a further realization of the previous one, when a reduction in the number of freight vehicles is a strong priority for the local government. Here, being part of a cooperation scheme would be compulsory for all carriers making deliveries to a specific urban area, or perhaps only for carriers involved in a specific sector, like less-than-truckload courier deliveries, for example. Transshipment areas (where loads are passed on from one vehicle to another) would be established by the authorities, where all goods would be transferred to the common carrier's vehicles. This common carrier might be one of the carriers involved in the

scheme, or an independent public-based company. The difficulty of imposing this type of cooperation on competing carriers, considering also that the additional transshipments involved account for additional distribution costs, has made it feasible so far only in large construction scenarios (Berlin, 2000).

Joint reception

A possible way to simplify goods deliveries in cities is the elimination of the multiplicity of delivery points, or at least of some of them, by delivering at the same point all the goods corresponding to a group of receivers. This point is assumed to fulfill all the requirements of accessibility and availability of parking space which the previous multiple drop points did not have. Thus delivered goods would then be picked up by the receivers themselves, at the most convenient time for them, for example before opening their premises in the morning or the afternoon. This avoids the need for carriers to access multiple drop points to deliver goods. It also has the added benefit of releasing receivers from fixed delivery schedules, although some compensation would have to be negotiated, if they are the ones who need to go and pick up their goods.

Solutions related to enforcement and promotion

Direct economic benefits

It is often found in feasibility studies that the assumption of new city logistics concepts, while enhancing livability in the city, reduce the effectiveness of the logistic chain, increasing costs for carriers and receivers. That is why the consideration of temporary tax reductions or direct subventions is reasonable in order to achieve a more sustainable mobility environment. Just as these policies are often used to encourage the use of less pollutant vehicles or public transport, they might also be considered to encourage other best practices, but it is important to note that it is a difficult measure to implement if the carrier is not based in the considered urban area.

City logistics forums

Any solution related to urban freight transport that is to be implemented in a city requires an agreement between all the involved stakeholders, or at least the previous consideration of all their opinions. An interesting issue is therefore the creation of a permanent forum where all these groups are represented, aimed at debating and, if possible, reaching consensus with respect to urban freight solutions (Van Bockel, 2001). This forum should not only address city logistics issues, but also all those aspects related to mobility in the city, due to the interrelationship between all types of transport in urban areas. The implementation of this solution in the shape of Freight Quality Partnerships seems to be yielding positive results in the United Kingdom (Department for Transport, 2003).

Information support

Since all the implemented urban freight solutions are expected to have an effect on all the city stakeholders, it is very unlikely that all these effects are beneficial. That is why a special effort must be made in order to disseminate to all parties involved the type of solutions that are intended to be implemented, as well as the reasons for those solutions to be preferred. This type of dissemination of city logistics issues might be accompanied by awareness campaigns, in order to involve citizens in freight transport within their city.

Driver training

This solution addresses the need to increase the skills of drivers and logistic companies in general related to city logistics. Since the objective is to achieve an improvement perceived by the whole community, this training, although supported by companies, may be initially promoted by the local administration. The training, depending on the specific situation of the urban area regarding city logistics, may be considered from two different points of view:

- From an individual point of view, in order to improve the behavior of city freight drivers with respect to issues like smooth driving for reduced pollution levels, lower noise levels, illegal parking, load/unload operations, enhancement of courtesy to other drivers (Ogden, 1992; European Commission, 2000).
- From a combined point of view, together with the introduction of other logistic solutions, in order to inform drivers of the expected best practices, the ways to adapt to the new scenarios, etc.

Alternative vehicles

A possibility to enhance the livability of congested urban areas is to grant priority access to vehicles with certain characteristics regarding the type of energy consumed, the type of engine, etc. A complete record of similar experiences can be found in (ELCIDIS, 2002), showing the benefits of such vehicles for city distribution. Two types of effects can be achieved with such regulations:

- Better environmental quality in case of hybrid or electric vehicles, either working on batteries or on fuel cells.
- Lower noise levels in case of silent vehicles, which might allow the combination of access allowance with night deliveries.

- Smaller vehicles suitable for entering pedestrian areas during shopping hours for deliveries.

The trend towards more restrictive environmental regulations in cities (Netherlands Ministry of Housing, 1991) makes this type of regulations a likely scenario in many medium–large cities, with the aim of achieving a modern, more sustainable vehicle fleet.

Identification systems

This type of systems allows the establishment of access controls for freight delivery vehicles or any other type of vehicles to certain areas of the city, parking lots, logistic terminals, etc. There exist different technologies for vehicle recognition, like magnetic cards, inductive identification, microwaves or infrared identification, but the most useful technology for a wide scale implementation seems to be the optical character recognition (OCR), tested with success in Genoa (PROGRESS, 2002). This technology reads symbols and characters automatically by means of digital cameras and interpretation software. It does not require any technology to be installed in vehicles, since the identification can be made by reading the license plate. These systems improve significantly the access control in cases of high vehicle flows, like in the case of accesses to commercial or business areas of a city like Rome (EuroPrice, 2002). They are not excessively costly for the city, and they constitute the most efficient way of controlling the entry to restricted urban areas.

CCTV

The use of close-circuit TV cameras for urban traffic control is becoming increasingly extended. With respect to city logistics, their application as an enforcement tool to guarantee the correct implementation of other solutions is one of the cheapest possibilities (García, 2001). However, the use of recorded images for driver punishment is usually not allowed by legislations, leaving cameras with only the mission of alerting the police, and the intimidation factor is thus very much reduced. Besides enforcement, cameras may, via the Internet, be used to supply information to carriers, regarding congestion, availability of load zones, etc.

Automatic bollards

This is the most widespread system for access control in cities, due to its functional and aesthetic characteristics. These bollards sink into the ground when an authorized vehicle arrives, thus allowing it to access the restricted urban area. Two types of configurations can be found:

- Controlled by radio, with a faster operation but forcing the vehicle to carry an emitting device.
- Controlled by a smart-card reader, easier and cheaper for the vehicle owner but with a lower traffic flow rate.

An example of the use of smart-card bollards is the access control pilot project carried out in Barcelona (Albors, n.d.). Other examples of the use of bollards for access control can be found in Liverpool or Cambridge.

Load zone surveillance

A current problem with load zones in many cities is their use as normal parking spaces by private cars. Usually the police do not have enough personnel to control these zones, and so one of the possible approaches might be self-guard, that is, an involvement of carriers in this control, where they would be the ones to call the police, or directly the crane, when a load zone was found occupied by private vehicles. A more difficult scenario appears when those vehicles belong to the shop owners themselves, that is, the carriers' clients; in this case, carriers would be much more reluctant to give notice to the police. Sometimes too, load zones are occupied by other freight vehicles which are overextending their use of the zones, not allowing other freight vehicles to park, in what is a difficult situation to detect by the police or by other carriers. The availability and correct operation of load zones is fundamental in the success of a city logistics system.

Route and access control

This solution is aimed at reorganizing freight transport flows in certain areas of the city, in case those areas contain streets which are to be banned for delivery vehicle traffic, or as a means to supply advice to carriers regarding which routes to follow (Just, 2000). The area should then be delimited and the access points identified, as well as the routes followed by freight delivery vehicles depending on the location of their delivery points. Accesses and displacements are then reorganized so that freight deliveries can be carried out without the need for entering the restricted streets. Route and access control can be performed in several different ways, the first two being related only to enforcement policies and the last one also to information purposes:

- By means of police controls: this is a costly option, and one which slows traffic flows significantly.
- By means of automatic bollards, programmed for granting access only to designated vehicles.
- By means of signaling: this is the cheapest option, but it requires additional control initiatives in order to guarantee the adequate observation of rules.

Expected effects

As stated at the beginning of the paper, the implementation of city logistics initiatives needs to keep in mind the conflicting objectives and interests of the different stakeholders involved in urban mobility. That is why they should be analyzed not only in terms of their effects on freight carriers, but also with respect to the point of view of the other stakeholders (Larrañeta et al., 1999a).

Solutions related to public infrastructure usually require extensive allocation of resources, unless they are implemented as a way of reutilizing existing infrastructure. These are strategic solutions, aimed at reorganizing logistic flows in the city, but generally involve a reduction in the efficiency of logistic systems. Unless high economies of scale are achieved, which is not straightforward in last mile distribution, the extra load transshipments account for extra costs, unaffordable for the reduced margins of urban freight distribution.

Therefore, although these solutions may prove to enhance the livability of the city and rationalize the flows of goods, countries like the Netherlands, where city terminals have been widely introduced, often come to the conclusion that the use of this infrastructure requires public support in order to achieve feasibility (Visser et al., 1999). Detailed cost-benefit analyses (Leleur, 1996) should therefore be carried out before attempting to introduce one of these solutions.

Solutions related to land use management have positive effects from the point of view of freight carriers, but are often rejected by other stakeholders, like residents, shop owners or persons who in general intend to drive their car to the city center. The allocation of more space, in highly dense and congested areas, to load/unload operations implies parallel reductions in the mobility and parking availability for passenger cars. Thus, the danger for the affected area of losing competitive edge with respect to other areas in the city is always a latent danger. However, these solutions are very appropriate for pilot implementations, since they often do not require specific regulations, and may therefore be discarded in case of failing to meet the expectations.

Solutions related to access conditions include two types of solutions. On one hand, there are those solutions usually easy to implement, accepted by carriers and normally not rejected by other stakeholders. They are solutions aimed at improving the performance of the existing city logistics system, without producing major changes but without generating major opposition. They should therefore be considered before thinking of more complicated and controversial measures. This group of solutions includes the introduction of access conditions according to the weight and volume of delivery vehicles, the implementation of security considerations and of access to pedestrian zones, and the establishment of vehicle rotations in load zones.

On the other hand, the rest of the solutions related to access conditions represent stronger attempts to induce significant modifications in the city logistics system, and in urban traffic in general, but they are likely to result in severe opposition from stakeholders whose interests have been damaged. For example, the introduction of double-parking short time restrictions, or the street blocking allowance, benefit the distribution of goods by harming general traffic, and access time windows cause the opposite effect. Night deliveries always count on the opposition of residents and shop owners, but they are suitable for pilot implementations in many individual cases. Finally, the closing of the city center to passenger cars and the introduction of road pricing schemes are the most radical solutions, which therefore cause the highest impacts on city logistics and general mobility, but are also the most controversial ones.

Within traffic management solutions, those related to the scope of regulations and to the use of information technologies may result beneficial for freight carriers, without generating opposition from other stakeholders. They should also, therefore, be considered in early stages of the planning process (Muñuzuri, 2003). With respect to cooperation measures, they are beneficial for general traffic in congested areas, due to the expected reduction in the number of delivery vehicles, but they are strongly rejected by carriers and receivers (shop owners) due to the inherent reduction in flexibility and carrier-receiver contact, as well as to the introduction of additional transshipments in the ''last mile'' logistic chain.

Finally, promotion and enforcement solutions are always considered as part of combined solutions, in together with one or more of the previous specific solutions. Enforcement measures guarantee more efficient results of the implementations, but also stronger opposition from affected stakeholders. Promotion techniques, on the other hand, are a proactive way of supporting best practices but represent higher expenditures for local public budgets.

Additional remarks

The specific solutions described here represent general tools to be used by the local administration in any general medium–large city. However, depending on the city, not all of them may be equally suitable, nor may they be applicable uniformly. Moreover, they might be implemented for the whole city or metropolitan area, or only to a specific part of it, where congestion and pollution problems related to urban logistic and other types of transport are specially relevant.

Some of these specific solutions benefit a certain group of stakeholders, but affect negatively those others. Thus, the challenge to urban planners is finding a combined solution that at the same time that improves freight distribution in the city and reaches equilibrium between the expectations of all stakeholders. Otherwise, those stakeholders whose interest has been damaged by the solutions should be somehow compensated. For example, receivers who are forced to pick up their own goods at a common reception point should perceive a certain economic benefit in return. If the cost reduction perceived by carriers is not sufficient to justify a reduction in the transport rates applied to shippers, which in turn leads to a reduction in the final price of the product, therefore compensating the receivers, then the solution is not feasible in that specific urban area. Pilot projects are being carried in many cities to find out if these equilibriums are possible, applying evaluation methods such as those described in Keeny and Raiffa (1976), Pearce and Nash (1981) and Saaty (1980). These methods, based on multicriteria and utility analyses, can be used to estimate numerically the impact caused on different stakeholders by the hypothetical implementation of a certain policy (Larrañeta et al., 1999b). They are therefore very useful for assessing opinions about complex scenarios, in which intangible motivations are to be considered.

Even when a suitable solution has been selected, according to a positive evaluation for all or most stakeholders, the transitory process to be followed until its full implementation requires attention from the planners. The final scenario might be a feasible one, allegedly better than the existing one, but the intermediate scenario, that which occurs during the implementation process and that might last for several months or years, might not be acceptable. Due to the critical social and political implications of urban mobility, detailed analyses are to be carried out before attempting to implement one of these solutions (Taniguchi et al., 1999).

Finally, even if congestion problems are significant in a city and the performance of the freight distribution system is not optimal, the expected results of the solutions listed here might not improve the outcomes of the existing policies. In that case, the best approach might be for the local administration to leave things the way they are, which is always one of the available options for a policy maker. Urban logistic solutions applied by the administration represent, in many cases, constraints on the free movement of vehicles, and thus they might damage the economic activity of the area where the solutions are applied, when compared to other areas of the city or other cities where there is less intervention by the corresponding local administrations.

References

Agostini, F, Bellini, R, Frosini, P and Gini, S (2003) Rapporto inerente specifiche di base per la realizzazione dei progetti elaborati localmente. Deliverable for Project Merope. Programma Interreg III-B, Mediterraneo Occidentale.

Albors, E (Unknown date) *Vehicle access control: Sistema de Identificación y Control del Acceso de Vehículos (SICAV)*. Municipality of Barcelona.

Allen, J, Anderson, S, Browne, M Y and Jones, P (2000) A framework for considering policies to encourage sustainable freight traffic and goods/service flows. Transport Studies Group, University of Westminster.

Barcelona City Council (2003) *Carril multiuso* (SMILE Project).

Berlin—Brandenburg Initiative (2000) Integrated Strategy for Freight Transport. Landesentwicklungsgesellschaft für Städtebau, Wohnen und Verkehr des Landes Brandenburg mbH (LEG).

Bestufs (2002) *Best Urban Freight Solutions: Best Practice Handbook Year 3*. European Community, Competitive and sustainable Growth Programme.

Button, K and Pearman, A D (1985) *Applied Transport Economics*. Gordon and Breach.

Certu (2002) Direction des transports terrestres. Plans de Déplacements Urbains et Marchandises en ville. Réflexions à destination des élus.

City of Glasgow (2001) *Local Transport Strategy*.

City of Melbourne (2004) *Pedestrian Area Access and Parking Permit Scheme*.

Dablanc, L, Bossin, P and coordinators (2002) Eléments pour le montage juridique d'un Centre de Distribution Urbaine (C.D.U.). Gart—Interface Transport.

Department for Transport (2003) *Freight quality partnerships, Case Studies*. Transport Energy Best Practice.

ELCIDIS (2002) Electric vehicle city distribution, Final Report. European Commission, DGTREN.

European Commission (2000) A sourcebook: good practice in freight transport. Office for official publications of the European Communities.

EuroPrice (2002) Guidance paper 3, Technical and Operational Issues. Mobility Agency of the City of Rome.

FREIA (1998) Towards the Networking of European Freight Villages. Final Summary Report, European Commision, Transport RTD Programme.

García, J (2001) Urban freight distribution in Barcelona. Barcelona Municipality. *First Bestufs Conference*, Barcelona.

Gloucester City Council (2004) *Pedestrian Area*. Centre of Gloucester Traffic Regulations.

Granada City Council (1997) Ordenanza General de Circulación y Ocupación de Espacios Públicos de la Ciudad de Granada.

Huschebeck, M (2002) *Deliverable D1.2, Recommendations for further activities. BEST Urban Freight Solutions*. European Union, Competitive and Sustainable Growth Programme (1998–2002).

Just, U (2000) Recommended urban truck routes—Bremen approach. Department of Construction and the Environment, City of Bremen. *2nd Bestufs Workshop*, Brussels.

Keeny, R L and Raiffa, H (1976) *Decisions with Multiple Objectives: Preferences and Tradeoffs*. John Wiley, New York.

Kitada, H (1992) The effect of trade custom on the goods flow by trucks. *The Road Transport Economy 1992-1* **58**, 47–58.

Larrañeta, J, Muñuzuri, J, Montero, G and García, J (1999) Evaluación de medidas sobre el transporte urbano de mercancías. Aplicación a Sevilla. *III Jornadas de Ingeniería de Organización*.

Larrañeta, J, Muñuzuri, J, Montero, G and García, J (1999b) Urban freight analysis and measures, application to the centre of Sevilla. In *Urban Transport V*, (ed.) L J Sucharov. WIT Press.

LEAN (1999) Integration of Lean Logistics into Urban Multimodal Transport Management in order to reduce space

requirements and optimize the use of transport. PL97-2113. DGVII European Union.

Leleur, S (1996) Transport project evaluation: integrating cost-benefit and multicriteria examination by the use of segregated investment return rates (SIRR). In *Proceedings of the 7th World Conference on Transport Research*, (eds) Hensher, King, and Oum. Elsevier Science.

Municipality of Copenhagen (2003) *The City Goods Ordinance.*

Muñuzuri, J (2003) La logística urbana de mercancías: soluciones, modelado y evaluación. PhD Thesis, University of Seville.

Netherlands Ministry of Housing, Physical Planning and the Environment (1991) Fourth Report (EXTRA) on Physical Planning in the Netherlands: Comprehensive Summary, On the Road to 2015.

Ogden, K W (1992) *Urban Goods Movement, a Guide to Policy and Planning, Ashgate.*

Pearce, D W and Nash, C A (1981) *The Social Appraisal of Projects, a Text in Cost—Benefit Analysis.* The MacMillan Press Ltd.

PROGRESS (2002) Pricing road use for greater responsibility, efficiency and sustainability in cities. *Deliverable 3.2*, Final Scheme Design Specifications. European Commission.

Robusté, F., 1999. Logística de la distribución urbana. I Congreso Internacional de Tráfico Urbano. Madrid.

Saaty, T (1980) *The Analytic Hierarchy Process.* McGraw-Hill.

Sta spa—*The Mobility Agency of the City of Rome (2002) City of Rome schemes*. Progr€ss project 2000-CM.10390.

Strauss, S (1995) City -Logistik in Kassel—Unternehmer helfen sich selbs,. Vortrag auf der Tagung, ''Gestaltung eines Umweltverträglichen Güterverkehrs'' in Rahmen der ''Utech 95'' in Berlin, 17.02.

Sustainable distribution, a strategy (1999) Department of the Environment, Transport and the Regions.

Taniguchi, E, Thompson, R G and Yamada, T (1999) Modelling city logistics. In *City Logistics I*, (eds.) E Taniguchi, R G Thompson. pp 3–37. Institute of Systems Science Research, Kyoto.

Taniguchi, E, Thompson, R G, Yamada, T and van Duin, R (2001) *City Logistics—Network Modelling and Intelligent Transport Systems.* Pergamon.

Tellus-Berlin (2004) Inner-City Logistics Centre. *Tri-modal logistics service.* Civitas Initiative, European Union.

Tellus-Rotterdam (2004) Access time window to promote clean commercial vehicles. *Civitas Initiative*, European Union.

Thoma, L (1994) Data Supply on the Report: *City-Logistics in the Freiburg City-District*, Chamber of Commerce, Freiburg.

Thoma, L (1995) *City-Logistik*. Deutscher Universitäts Verlag.

Transport for London (2003) Congestion charging—6 months on.

Van Bockel, R (2001) Physical distribution in urban areas, the Dutch experience. *Bestufs Conference*, Barcelona.

Van Duin, J H R (2002) *City Distribution by Railways? A Feasibility Study of the City of Graz. Urban Transport VIII.* WIT Press, pp. 111–120.

Visser, van Binsbergen and Nemoto (1999) Urban freight transport policy and planning. In *City Logistics I*, (eds) E Taniguchi and R G Thompson. Institute for City Logistics.

Watson, K (2002) Night freight to hush up. *Noise Management Newsletter.*

Wegmann, F J, Chatterjee, A, Lipinski, M E, Jennings, B E and McGinnis, R E (1995) *Characteristics of urban freight systems. Federal Highway Administration.*