7th Framework Programme
Theme 7: TRANSPORT (including AERONAUTICS)
CONDUITS, Coordination Of Network Descriptors for Urban Intelligent Transport Systems
Contract n° 218636

K. Zavitsas, I. Kaparias, M.G.H. Bell

conduits@imperial.ac.uk

Reviewed by:
M. Tomassini

Transport problems in cities

Deliverable No. 1.1

DISSEMINATION LEVEL : PUBLIC

Title: Transport problems in cities **Version:** v.3	**WP no.:** 1 **Deliverable no.:** 1.1
Planned submission date	11/08/2009
Actual submission date	10/09/2010

Document history	**Version**	**Comments**	**Date**	**Issued by**
	v.1	Initial submission	19/03/2010	Imperial
	v.2	Revised submission	09/07/2010	Imperial
	v.3	Final submission	08/09/2010	Imperial

Number of pages:	36
Number of annexes:	0

Responsible organisation: Imperial College London	**Principal Author(s):** Konstantinos Zavitsas Ioannis Kaparias Michael G. H. Bell
Contributing organisation(s):	**Contributing Author(s):** –

Quality Control	**Organisation**	**Date**	**Result**
v.1	ISIS	06/05/2010	Rejected
v.2	ISIS	13/08/2010	Accepted with revisions
v.3	ISIS	10/09/2010	Approved for delivery

Table of contents

Executive summary

The objective of this study has been to understand the city context and set out the background for a review of traffic management and Intelligent Transport Systems (ITS) in cities in Europe and beyond. To identify the major transport problems that cities are faced with, primary and secondary research was carried out. With respect to the latter, a thorough literature review on transport problems in cities has been conducted, including a review of measures, policies and technologies that have been implemented worldwide. To complement this, however, primary research has been undertaken, whereby representatives from 16 cities have taken part in two focus groups at the 1st CONDUITS Technical Workshop. The aim of the first focus group was to ask each city representative directly about the needs and priorities of his/her city, about the main transport problems and about the role that ITS play or can play in resolving these problems. The cities' representatives were also encouraged to engage in a discussion between themselves so as to identify the main common challenges.

Summarising the results, the importance of efficient urban transport has been highlighted, among others due to its close relationship with economic prosperity and development. However, providing efficient transport is associated with dealing with a number of problems, which have been categorised in five broad areas: land use; congestion; car dependence; environment; and other issues, which include safety, political difficulties and economic prosperity. Most cities have taken or plan to take action to address these problem areas in order to achieve their short- and long-term objectives, which include changing the modal split in favour of more sustainable travel modes, reducing emissions, decreasing road accidents, etc. An important additional issue that was identified is the fact that city transport authorities are very often confronted by political difficulties, difficulties in communication between organisations, and difficulties in sharing information.

ITS seem to play an important role in urban traffic management, as cities place them fairly high in their priorities. They are generally considered as offering potential solutions to many of the cities' problems, with the vast majority of the cities having implemented ITS technologies in terms of providing information to the public and facilitating traffic management, or planning to do so in the coming years.

Despite cities having different characteristics and individualities, however, it has been found that they share common problems and objectives. However, each city at the moment tends to be autonomous and act in response to its own political pressures, making it very difficult to build an overall picture of how transport policies are being used to provide solutions and how effective these are. The development of a common evaluation framework can assist in overcoming this issue, and cities see great potential in a set of Key Performance Indicators (KPIs), which would evaluate and assess traffic management policies and ITS.

1 Introduction

Transport has a major impact on the spatial and economic development of cities and regions. The quantity and quality of transport infrastructure influences the attractiveness and desirability of urban regions [*1*]. An interesting approach to the topic is provided in the preface of the book "The Economics of Urban Transportation" by Kenneth A. Small and Erik T. Verhoef [*2*], who suggest that: "At the heart of all modern economic activity is trade. People trade labor and ideas for cash, and cash for goods and services; firms trade technology, expertise, financial capacity, intermediate goods, administrative functions, and many other things with each other, with individuals, and with governments. All these transactions require communications and most require transport of goods or people – to work, shopping, tourist sites, meeting locations. Thus it is fair to say that transportation is central to economic activity".

The close relationship between transport and trade justifies the existence of cities, since there are advantages in carrying out economic activities in proximity. Such advantages are often called "economies of agglomeration", referring to certain groups of activities located close to each other because of lower cost. The primary reason for agglomeration economies, especially in a world with low communication costs, is that transport costs are still significant and proximity reduces them. A corollary is that anything that reduces transport costs within an urban area increases the extent to which its activities are easily linked to each other, and thus takes further advantage of agglomeration economies. In a world of many competing urban centres, those with more efficient transport systems have an advantage.

Naturally, providing an efficient transport system in a city to enable the smooth mobility of people and goods does not come at no cost. Cities today are faced with many problems, many of which are arising from the transport system itself and present themselves as barriers to providing efficient transport and at the same time ensuring good quality of life. Focussing on road transport, the purpose of this report is to identify the main transport problems that cities face today and thus create the basis for assessing the impact of traffic management policies and strategies introduced by cities.

The approach used to obtain the information needed to compile this report is a primary and secondary research based one. The secondary research consists of a thorough review of existing literature on transport problems faced by cities. As transport has been recognised as an important aspect of city life in the last decades, a substantial amount of literature tackling the issue of transport problems in cities is available. To complement it, however, primary research has been conducted with a help of a focus group, as part of the 1st CONDUITS Technical Workshop, in which representatives from 16 European cities were given the opportunity to present the problems they face and the priorities they have, and to participate in an interactive discussion.

The cities that participated were (in alphabetical order): Athens (Greece), Barcelona (Spain), Brussels (Belgium), Dublin (Ireland), Haifa (Israel), Istanbul (Turkey), Kocaeli (Turkey), London (UK), Rome (Italy), Sheffield (UK), Stockholm (Sweden), Stuttgart (Germany), Tel Aviv (Israel), The Hague (The Netherlands), Turin (Italy) and Zurich (Switzerland). The following five broad areas have been identified as the main transport problems that cities face today: land use; congestion; car dependence; environment; and other issues, which include safety, political difficulties and economic prosperity. All these are examined in the present report. Intelligent Transport Systems (ITS) clearly play an important part in resolving these problems and as such, their role is analysed.

The report is structured as follows: Section 2 investigates the importance of land use in transport planning and the problems associated with it. Section 3 tackles the problem of congestion, including parking scarcity. Then, the issue of car dependence in modern cities is looked at in Section 4, including the target of most cities to change the modal split, and Section 5 deals with the environmental issues of transport in cities and with fuel efficiency. Further problems are described in Section 6, such as the political difficulties affecting transport decisions. Section 7 then defines the role of ITS in resolving transport problems in cities, and Section 8 concludes the report, setting the foundation for assessing the impacts of traffic management policies.

2 Land use

The relationship of transport and land use is a bidirectional one. On one hand, transport affects the nature of an urban area itself, since participants in an economy would have no reason to locate close to each another if transport were costless economically and time-wise. The way land at certain locations is used, the types and densities of buildings occupying them and the activities that occur there are among the most important factors influencing travel decisions. For example, research has shown that public transport ridership in a city is more heavily influenced by the number of jobs in the city's central ("downtown") area than by almost any other factor [*3*].

On the other hand, the provision of transport can be a challenge under certain land uses, depending on the characteristics of individual areas. Namely, in inner city areas with high building and population densities it can be proven difficult to provide efficient transport links and infrastructure, whilst at the same time ensuring a high level of quality of life (e.g. safety, environmental sustainability etc.). Many cities are thus considering the option of reallocating road space between different road user groups (e.g. give more space to public transport and pedestrians) in order to address the issue. The concept followed mainly depends on the priorities of the city at a given time, as well as on the architectural perceptions of the time.

The issues faced by cities, therefore, with respect to land use, can be distinguished in "macroscopic" (high-level) and "microscopic" (low-level) ones. The former relate to considerations, such as the development of new areas and their uses and the provision of transport in order to promote certain land uses, while the latter are concerned with reallocating road space with the aim of addressing the needs of established land uses, which are not covered by the existing infrastructure configuration.

2.1 Macroscopic land use issues

To achieve a better understanding of the influence of transport in a city's land use, it is required to study the relationship between urban density and travel measures, typically at the level of a metropolitan area. One needs to keep track of which is causing which, and to carefully distinguish related factors. For example, it is important to acknowledge the influence of variables like income and fuel price, which are correlated with land use characteristics and independently affect travel. Some studies analysing the effects of urban density on travel, such [*4*], have been severely criticised for neglecting this fundamental requirement of statistical analysis. It is also important to note that land use patterns also have an effect on transport, implying a two way relationship. Hence, explaining travel decisions in terms of land use patterns risks confusing the cause with the effect, which thus points to the need of introducing exogenous explanatory variables related to land use, such as the age and location of the city.

Even when the bi-directional relationship between transport and land use is adequately modelled, surprising policy paradoxes may occur. Examples of this include the so-called "induced demand" phenomenon, where expanding highways to relieve congestion may attract development that undermines the intended effect, but where expanding public transport may indirectly increase highway congestion because the induced development, even if public-transport oriented, still generates many car trips [*5*]. A further problem is that land use patterns cannot be modified without strong cause. Even in countries with strong land use authority land use policies do not always bring about the changes that were intended; in others, the changes in land use that can feasibly be accomplished through policy are rather limited [*6*].

Empirical evidence on how land use affects travel demand in an entire metropolitan area exists from the Netherlands, where it was found that for any given mode (car or public transport), the largest cities have the shortest and fastest commuting trips, medium-sized cities and rural "growth centres" have the longest, while suburbs are somewhere in between. Exceptionally high use of walking and cycling was also identified in the largest cities, with lower rates in other areas [*6*]. Looking at empirical studies from the USA, across a number of metropolitan areas in the USA, fuel consumption per capita was found to rise with total urban population and with the fraction of jobs located in the city centre and to drop with the fraction of people living in high-density areas [*7*]. Also, in another study, commuting time was found to increase with residential density, reflecting longer or more congested commuting trips, but to drop with the proportion of the metropolitan population that lives outside the city centre [*8*]. However, it should be noted that the quantification of the effects of land use on transport and vice-versa also strongly depends from further city-specific characteristics, making it difficult for a generic model reflecting these to be derived [*9*].

Looking at the neighbourhood level, it is clear that high-density neighbourhoods located near public transport stops support higher use of public transport, but it is less clear how much of this effect is intentional, i.e. how many of those who want to use public transport choose to relocate to areas with good public transport accessibility [*10*]. This is further complicated by the fact that people often travel greater distances than required by the land use patterns alone, such that even when a "jobs and housing" balance is achieved within a community, people do not necessarily choose local jobs. In fact, it is very common in western cities that residents move increasingly away from the city centre (e.g. Figure 1). This also introduces demographic issues, as the people relocating are mostly families, thus leaving an ageing population in inner city areas and creating the need to attract younger people.

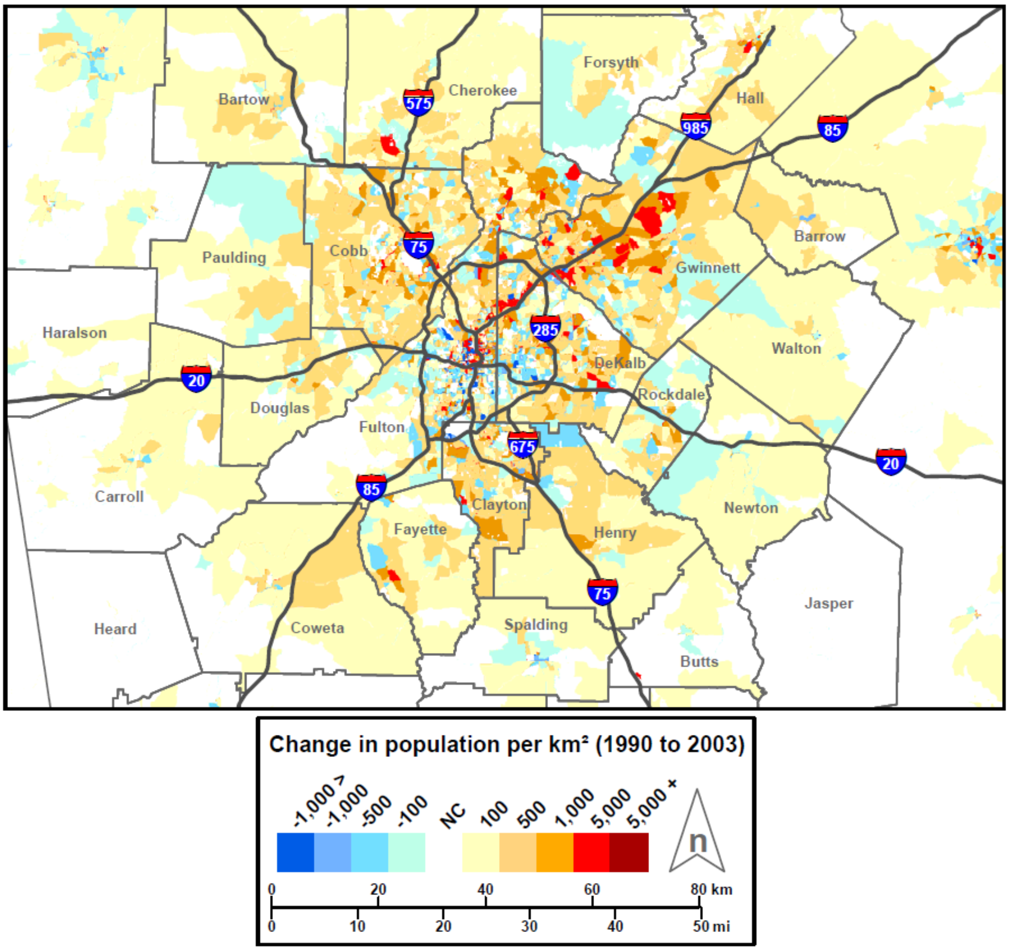

Figure 1: Urban sprawl in Atlanta, Georgia, USA (source: Portland State University)

As such, cities are faced today with the problem of how to predict and influence land use patterns, as this is not generally straightforward. However, land use also poses further problems to cities at a lower level.

2.2 Microscopic land use issues

Street design has experienced big changes during the last half-century, moving from clearly car-oriented schemes to integrated design and shared space. Namely, in the 1960s and 1970s, the priority of western city authorities was to ensure the smooth flow of car traffic in urban areas, as the car was deemed the transport means of the future. Given that pedestrians were not only a nuisance but also a hazard (involved in many accidents with cars), the street design concept followed at the time was based on the complete segregation of pedestrians and vehicles, as lucidly set out in Buchanan's monumental "Traffic in Towns" report in the UK [*11*] (Figure 2). According to this, vehicles should be able to cruise through built-up areas in wide multi-lane highways, never meeting pedestrians, who would be restricted by guardrails, walls, footbridges and pedestrian subways to their own parallel universe.

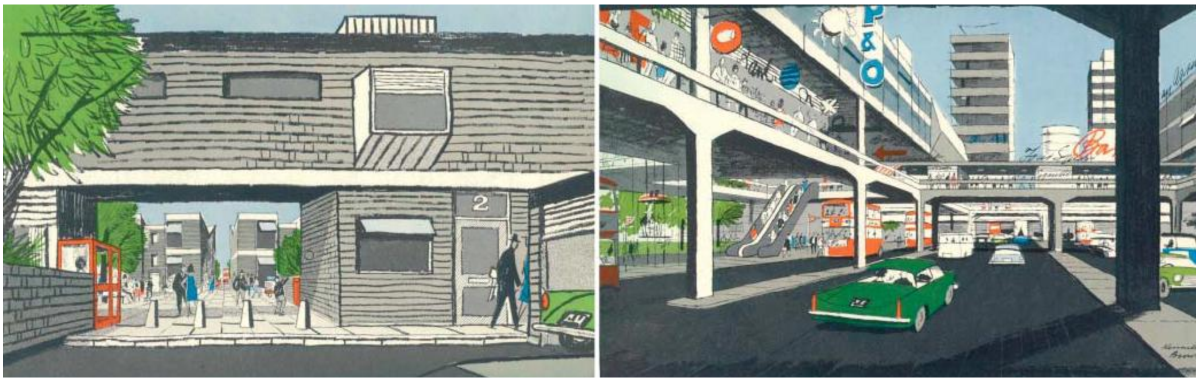

Figure 2: Segregation of cars and pedestrians [*11*]

In recent years, however, the above described concept has been deemed by some detrimental for urban environments due to its perception as resulting in "the domination of vehicular traffic and associated noise and air pollution alongside street clutter and ugly surroundings" [*12*]. Also, as mentioned in Section 2.1, it became apparent with time that providing supply in road space does not in fact satisfy existing demand, but additionally encourages more car drivers to use the road (induced demand). Hence, the primary objective of ensuring smooth traffic flow in a city, expected to be ensured by constructing large highways in the 1960s, had ceased to be met, as cities were now faced with large numbers of congested highways (see Section 3). Consequently, there has been a trend of moving away from segregation of pedestrians and vehicles, which has also been driven by developments in architecture, towards the concept of integration and traffic calming (Figure 3) as a means of creating a nicer environment, but also as a way of improving traffic efficiency and road safety, mainly due to the introduction of ambiguity, which makes both drivers and pedestrians more vigilant [*13,14*].

Figure 3: Integrated urban street design

Modern street design aims at asserting the function of streets as places rather than as arteries. However, cities today are faced with the problem of infrastructure not meeting its intended purpose. For example, many European cities have central areas consisting of congested roadways and bulky pedestrian- and cyclist-unfriendly infrastructure, thus diminishing the quality of life in these areas. Large cities in developing countries go even further and provide additional road infrastructure to address the booming demand of car trips. Reallocation of road space is thus a central issue for modern city authorities, who seek ways of combining a successful and efficient transport planning process with the integration of sustainability in urban design, while making the most of existing infrastructure. This includes identifying the needs of road users and promoting features, such as cycle lanes, tram lines and pedestrian zones.

3 Congestion

Congestion has become one of the most important aspects of modern life in big cities. The dimension of the problem can be realised by simply considering that one third of all vehicular travel takes place under congested conditions, in which speed averages half the free flow values. Congestion occurs when transport demand exceeds transport supply in a specific section of the transport system. Under such circumstances, each vehicle impairs the mobility of others [*15*].

The problem of congestion was identified already in the 1960s [*16*], and its source is that urban transport growth is skewed heavily in favour of road transport, thus leading to a substantial growth in congestion. The rise in congestion increases the emissions and the energy consumption per passenger-km, making road use increasingly unsustainable. Congestion also has a negative economic impact, as the efficiency and the throughput capacity of a congested transport system reduce substantially. Furthermore, since vehicles spend the majority of the time parked, motorisation has expanded the demand for parking space, which has created space consumption problems particularly in central areas. The spatial footprint of parked vehicles is significant.

The problems of road congestion and parking are described next.

3.1 Road congestion

The second half of the 20th century saw the rapid expansion of the road network in rural and urban areas; in the case of the latter, roads were originally designed for speed and high capacity, but often the urban growth occurred at a rate higher than expected. The view was to provide accessibility to cities and regions, with the primary incentive for the expansion of road transport being the provision of high levels of transport supply. Nevertheless, this has created a vicious circle of congestion, which supports the construction of additional road capacity and results in increased car dependence (see Section 4). Naturally, cities have reached the situation where they cannot improve infrastructure at a rate similar to the growth in travel demand, such that the capacity is reached or even exceeded in almost all metropolitan areas. In the largest cities such as London, road traffic is actually slower than it was 100 years ago, with average speeds continuing to decrease (see Figure 4).

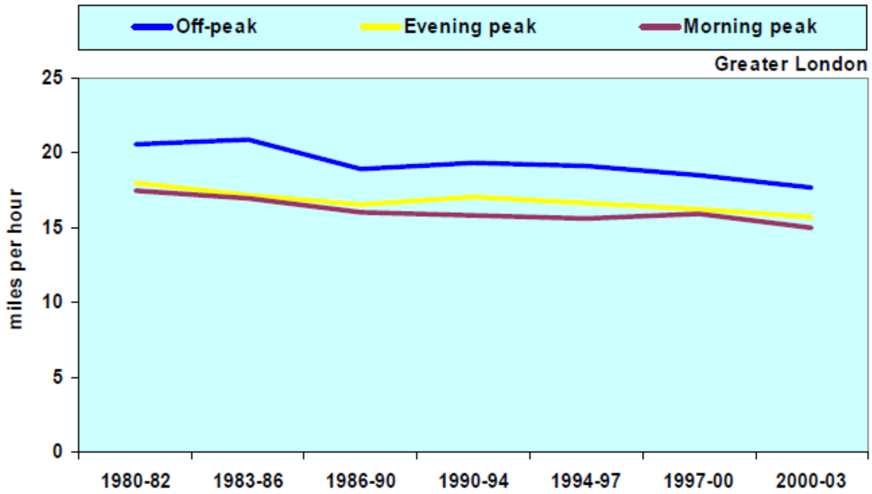

Figure 4: Average traffic speeds in Greater London [*17*]

With increased incomes in many regions of the world, to the extent that more than one vehicle per household is common, flexibility in terms of choice of origin, destination and travel time has increased. Trips can be categorised as commuting trips (between work and home) and leisure trips, with the former often being performed within relatively schedules, and the latter following variable and discretionary schedules. Mobility patterns have a significant impact on congestion patterns, which can in turn be categorised as recurrent and non-recurrent.

Recurrent congestion can have unforeseen impacts in terms of its duration and severity. Commuting trips are mainly responsible for the peaks in traffic flow, implying that about half the congestion in urban areas is recurring at specific times of the day and on specific segments of the transport system. Non-recurrent congestion, on the other hand, is caused by random events, such as accidents or unusual weather conditions (rain, snowstorms, etc), which are unexpected and unplanned. Non-recurrent congestion is linked to the presence and effectiveness of incident response strategies. As far as accidents are concerned, their randomness is influenced by the level of traffic, as the higher the traffic on specific road segments the higher the probability of accidents [*18*].

Road congestion in cities, however, is not only concerned with the transport of people, but also with freight. Namely, several industries have shifted their transport needs to goods vehicles (LGVs and HGVs), thereby increasing the usage of road infrastructure. Since cities are the main destinations for freight flows (either for consumption or for transfer to other locations), the urban movement of goods is a significant contributor to congestion in cities.

The final leg of the supply chain problem remains particularly vulnerable for freight distribution in cities, introducing great uncertainty. Congestion is often associated with a drop in the frequency of deliveries, with logistics operators needing to provide additional capacity (bigger vehicles) to ensure a good level of service.

An important contributor to congestion is the provision and quality of traffic information; namely, road users today have access to a substantial amount of traffic information, notifying them of congested roads in real-time, so that they can avoid it and save time. The use of this information, nevertheless, can have the opposite effect, as many city authorities have observed what is known as “congestion feedback”. Congestion feedback is the situation, where a large number of vehicle drivers obtain the same information about a congested road and are supplied with the same alternative route (over the radio, mobile phone, navigation system, Variable Message Signs (VMS) etc), such that congestion is created where there was none before. In other situations, certain information can create congestion due to a large number of vehicles going to a single location (e.g. if there is a fire in a tunnel, people will go to see what happened), or due to the information being wrong (e.g. a goods vehicle being guided along a narrow road, blocking back the traffic). It is thus important to ensure that the information provided is reliable and to take its congestion-related consequences into account.

A number of measures and policies have been implemented around the world to tackle congestion. These include ramp metering on congested highways, high-occupancy vehicles schemes (e.g. high-occupancy lanes, car pooling etc), congestion pricing, efficient incident management, promotion of public transport etc. A common framework to assess their impacts and performance, however, is needed.

3.2 Parking

Coupled with road congestion, parking is another form of urban congestion, but its effects are different. Parking has a significant imprint on land use, as it consumes large amounts of space. In largely car-dependent cities, this can be very constraining as each economic entity has to provide an amount of parking space proportional to its level of activity. Therefore, parking has become a land use that greatly inflates the demand for space in a largely inefficient way. Land use planning textbooks rarely mention parking congestion and requirements, indicating that the issue has often been neglected and underestimated by urban planners. As in the case of road congestion, cities are often required to provide additional parking space with growing demand in order to ensure economic development. The construction of large underground and multi-storey parking areas is a commonly applied practice, which, however, has a high implementation cost with often unconvincing results. Besides, as in road congestion, the provision of additional capacity also results in induced demand, which then needs additional capacity to be met. The limited availability of space in city centres and the financial implications, thus, force stakeholders to search for alternatives.

To overcome parking congestion it is essential to accurately determine parking space requirements and to understand the origins of demand. It has been established that economic activities generate trips which further generate parking requirements; however, there is a great variety in the parking demand depending on the nature of each activity. What is more, induced demand is often noted when parking is offered free of charge, and hence, determining the minimum parking requirements for different economic activities and attempting to meet them has been found to be an inadequate method to address the problem and to relieve parking congestion. This is because the minimum parking requirements are based on the assumption that the demand for parking does not depend on its price and that the supply should not depend on its cost. Neglecting the pricing and cost elements is unreasonable, as the land market cannot be regulated to meet these assumptions. Charging policies, on the other hand, allow for the counterbalance of demand by pricing, enabling transport and urban planners to overcome parking congestion and utilise land in better ways [*19*].

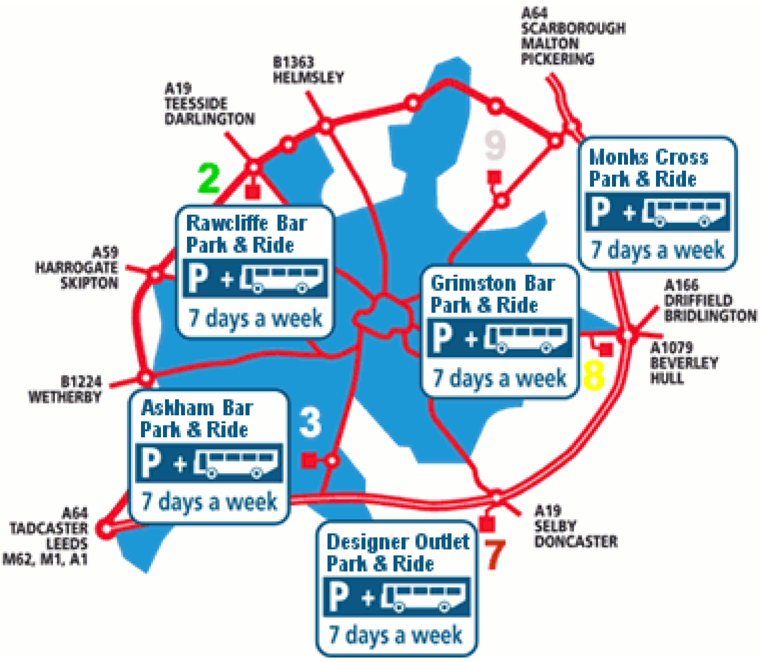

Figure 5: Park-and-ride scheme in the city of York, UK

Parking demand relaxation can also be an indirect benefit of methods addressing traffic congestion, such as high-occupancy vehicle schemes (car pooling, car sharing etc.) and congestion pricing. This is explained by the proportional relationship between trip generation and parking demand in urban areas (less car trips means less cars seeking parking in an area) and is in line with the cities' main objective of achieving a modal shift from private transport to more sustainable modes (see Section 4). With respect to the latter, parking may also play an important role, as it can be integrated with public transport in the form of park-and-ride. Namely, the fact that the majority of trips to city centres originate from outskirts, rural areas or other cities, has made the development of park-and-ride facilities a common practice that supports the usage of public transport in city centres and integrates private and public means. An example from the city of York in the UK is shown in Figure 5, where parking is integrated with the bus network. Park-and-ride sites are located in peripheral lower-density areas and are mainly operated as public transport connectors. In some cases, even so-called "integrated" tickets are available, enabling travellers to pay for their parking fee and public transport fare using the same ticket.

Another parking-related problem in cities regards the efficiency of locating parking spaces. It has been observed that vehicles spend unnecessary time and fuel searching for a parking space, while substantially contributing to road congestion at the same time. To ease the process of locating free parking spaces, dynamic parking management systems have been developed and implemented in cities, assisting drivers by providing real time information on parking space availability through dynamic signs on the roadside or through personal navigation systems. Such systems significantly improve urban parking management, contributing to addressing the issue of parking congestion.

4 Car dependence and modal shift

The issue of car dependence, which is one of the main causes of congestion and air pollution, is described here. Then, the cities' objective with respect to reducing car dependence and achieving a modal shift from private transport to public transport, walking and cycling, is explained.

4.1 Car dependence

As mentioned in Section 2, in the 1960s and 1970s the car was deemed the transport means of the future; however, in the last decades car dependence has been identified as an issue of paramount importance for transport planners due to its large economic and social impacts. Namely, car dependence is one of the main causes of congestion and also has further negative impacts with respect to environmental and efficiency issues, as cars are linked to several types of environmental hazards, including air and noise pollution, and the consumption of non-renewable resources (also see Section 5).

European data suggest that in 2004 there were 495 cars per 1000 inhabitants on average in the EU-15 countries, with the equivalent EU-25 average being [*20*]. Namely, in Table 1, which illustrates car ownership trends in the EU member states and candidate countries, it can be seen that at the upper end of the member states, Luxembourg had 659 cars per 1000 inhabitants, while Italy and Portugal had around 575, whereas at the lower end, Hungary and Slovakia had 282 and 225 cars per 1000 inhabitants respectively. A further observation that can be made is that in most European countries car ownership has steadily increased between 1990 and 2004, with particular increases in the new member states and candidate countries between 1997 and 2004. Notable examples of the latter are: Latvia with a 71% increase, Lithuania with 61%, Bulgaria with 52%, Poland with 42% and Cyprus with 41%. It becomes thus clear, that car ownership is steadily increasing in Europe, which naturally results in higher car use in cities.

It is clear that there is a strong connection between car ownership and economic prosperity. While the car is not a luxury good in our days but has rather become a consumer good, changes in car ownership levels still demonstrate changes in wealth. It is noteworthy that some countries have seen radical car ownership increases since their entry in the EU; examples include Portugal and Greece that have experienced 205% and 103% increases respectively between 1990 and 2004. However, economic prosperity is not the only factor causing the increased car use in cities; other factors include the advantages of car travel (on demand mobility, comfort, speed and convenience), as well as the cities' infrastructures (or lack thereof), which strongly favour private over public transport, thus making the former more attractive to travellers.

Table 1: Car ownership in Europe [*20*]

Countries	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2004	Countries
AT	387	399	410	421	433	447	458	469	481	496	506		501	AT
BE	388	398	400	408	413	422	427	435	440	449	458		467	BE
BG								207	218	232	243	256	314	BG
HR													301	HR
CY								317	334	342	355	369	448	CY
CZ								329	339	334	335	344	373	CZ
DK	309	310	310	312	312	319	331	337	343	347	347		354	DK
EE								293	310	317	322	298	350	EE
FI	389	385	384	370	368	372	379	380	392	404	413		448	FI
FR	415	419	418	423	430	433	437	446	456	466	463		491	FR
DE	447		471	479	488	495	500	504	508	516	521		546	DE
EL	171	174	177	189	199	211	223	238	254	275	304		348	EL
HU								226	219	223	235	248	280	HU
IE	227	238	241	249	262	265	272	309	324	340	343		385	IE
IT	483	503	518	520	524	529	531	535	545	556	563		581	IT
LV								174	196	215	234	248	297	LV
LT								238	255	294	317	307	384	LT
LU	480	523	512	523	540	559	558	562	594	610	623		659	LU
MT								491	464	482	497	499	525	MT
NL	368	371	373	376	383	364	370	378	382	398	411		429	NL
PL								221	230	240	258	272	314	PL
PT	187		205	224	242	258	277	297	321	330	350		572	PT
RO								115	125	133	139	144	149	RO
SK								211	222	229	236	239	222	SK
SI								392	410	429	437	444	456	SI
ES	309	322	336	344	351	362	376	389	408	428	442		350	ES
SE	421	421	414	409	409	411	413	418	428	439	451		456	SE
TR								56	59	62	66	67	75	TR
UK	360	373	360	366	372	374	388	399	404	414	419		463	UK
EU-15	394		409	414	422	426	434	442	451	460			495	EU-15
EU-25													463	EU-25

[Source of this data: Eurostat]

Nevertheless, with more and more households having access to multiple cars and hence increasing car travel demand that the existing infrastructure cannot support, the problems of congestion and lack of parking are severely aggravated in cities. Car dependence, therefore, is an undesirable phenomenon for cities, which look at reducing it as much as possible. The policies and strategies used for that purpose are similar to the ones used for tackling congestion and are mainly based on car dissuasion.

Car dissuasion can be achieved by imposing regulations that restrict car access or increase the cost of car use. Pricing policies, similar to those used to address road and parking congestion, can play an important role in the decisions of individuals. In many European cities car use is discouraged through high taxation on both petrol and car ownership. Furthermore, traffic management measures such as access control schemes prohibiting car traffic in central urban areas are a common practice aiming to protect the ambience and the physical infrastructure of a city centre. Pricing schemes such as imposing tolls for parking and entry to congested parts of a city have been considered by several cities, as they confer the potential advantages of congestion mitigation and revenue generation. Such policies let the price regulate demand and most evidence underlines that the drivers are willing to bear additional toll costs only when car use is linked with their main income [*21*].

However, car dissuasion alone cannot bring about the desired reduction in car dependence, as travellers need alternatives. Namely, discouraging car use but keeping an inadequate public transport infrastructure is likely to not only fail to achieve the desired reductions, but also to frustrate the public, who will perceive this as an unpopular policy and will take it into account in the next election. As such, car dissuasion policies can only be effective if they are coupled with strategies promoting public transport, so as to enable a modal shift.

Overall, the idea of sustainability appears to be gaining ground as it influences transport policies at a global level. Under the current environmental concerns and the urge for sustainability in transport, there is now a need for cities to try to improve the performance of their transport systems in terms of efficiency, while simultaneously improving their residents' amenity and living environment. Therefore, it is in the interest of cities to evaluate the individual and perhaps disjointed policies and strategies they have suggested over the years for helping to alleviate car dependence and bring them together under the unifying concept of sustainability.

4.2 Modal shift

Achieving a modal shift from private transport to public transport, walking and cycling, is the primary objective of most transport planning city authorities. With the constantly increasing travel demand and the increasingly insufficient private transport infrastructure, public transport in cities presents many advantages, not only in terms of sustainability, but also in terms of efficiency. Having greater passenger capacity and a considerably smaller environmental footprint per capita, public transport has become a viable and sustainable alternative to the congested highways of densely populated inner city areas.

Nonetheless, looking at Table 2, which illustrates the overall modal split of inland transport in different countries in Europe in 2009, it can be seen that while the percentage of private transport varies between different countries, it is always considerably higher than the share of public transport. Namely, taking the EU-27 average, 83.4% of the total passenger-km travelled occurred by private transport, with buses and rail accounting for less than 15% in several countries, such as Lithuania, the Netherlands and the UK. It is also noteworthy that even in countries with a higher public transport share (such as Hungary and Bulgaria) the car was still preferred mode of travel. Of course the statistics shown here reflect the total trips in each country rather than just urban travel, for which the public transport share is higher (especially in large metropolises); also, the figures only refer to motorised trips, with the shares of walking and cycling not being included; however, these figures still point to the fact that that public transport usage is generally low compared to private transport as a result of car dependence, and that there is scope for a modal shift. Findings from the CONDUITS D1.2-1.3 report confirm this (Figure 6), as it can be seen that from 37 cities examined, about half have private transport shares of 50% and above, with public transport having a much smaller share in all cities, with only a few notable exceptions.

Table 2: Modal split of inland passenger transport [*22*]

	(% of total inland passenger-km) (1)		
	Passenger cars	Buses	Railways, trams and metros
EU-27	*83.4*	*9.5*	*7.1*
Belgium	79.9	13.1	7.0
Bulgaria	*64.3*	*30.4*	*5.3*
Czech Republic	75.6	16.9	7.5
Denmark	79.8	11.2	9.1
Germany	*85.7*	6.5	7.8
Estonia	76.0	22.0	2.0
Ireland	*76.1*	*18.8*	*5.1*
Greece	*76.3*	*21.9*	*1.8*
Spain	82.6	12.0	5.4
France	*85.3*	*5.3*	*9.4*
Italy	*81.9*	12.1	5.9
Cyprus	:	:	0.0
Latvia	76.2	18.2	5.6
Lithuania	90.5	8.5	1.0
Luxembourg	*85.3*	*10.8*	*3.9*
Hungary	*63.2*	*23.8*	*13.0*
Malta	:	:	0.0
Netherlands	*87.5*	*3.8*	*8.7*
Austria	79.4	10.3	10.3
Poland	82.5	10.6	6.9
Portugal	*82.8*	*12.8*	*4.5*
Romania	*74.0*	*15.6*	*10.5*
Slovenia	85.6	11.4	3.0
Slovakia	*72.7*	21.2	6.1
Finland	84.9	10.3	4.8
Sweden	84.1	7.5	8.4
United Kingdom	87.4	6.5	6.1

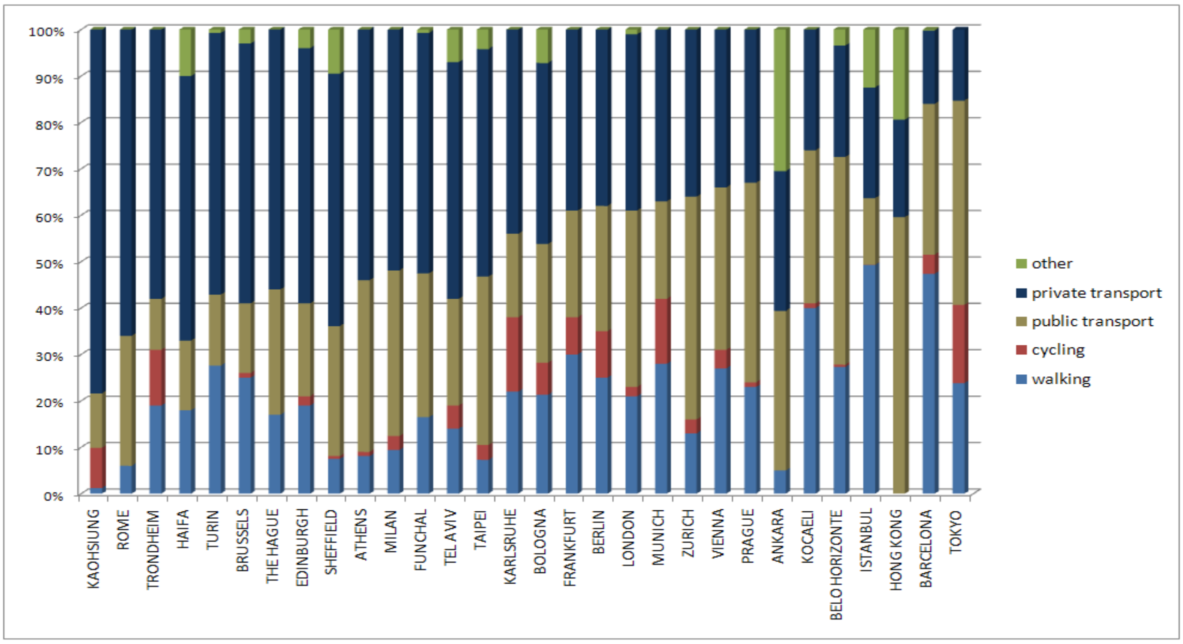

Figure 6: Modal split in 37 cities (%) [*23*]

In order to achieve a modal shift and drive people away from cars and onto public transport, walking and cycling, two categories of methods are needed: car dissuasion, to make car use less popular, and promotion of the other modes, to make them attractive alternatives. Car dissuasion methods were focussed on earlier in the report as methods aiming at reducing car dependence, so the promotion of other modes is discussed here. An important consideration that should be made is that when making a choice of travel mode, travellers will always compare the strengths and weaknesses of each mode, not only in terms of cost (which is important but not necessarily decisive), but also in terms of total travel time, reliability, walking distance required, comfort etc. A shift away from private transport will only occur when travellers find it less beneficial than other modes.

Looking at public transport, the main factors affecting its demand are fares, the quality of service and the cost of competing modes [*24*]. While the fares and the cost of the competing modes are only a matter of policy making and can be set relatively simply, the quality of public transport is a slightly more complicated matter, as it is defined by various factors, such as the frequency of service, the time spent on board the vehicle, the waiting and travel environment, the provision of information, the number of interchanges and the reliability. Therefore, the existence of a fairly dense public transport network, offering fast, easy and comfortable access (e.g. with modern and comfortable vehicles, offering accessibility to disabled passengers) to all areas of a city is the most important requirement.

With respect to the operation of public transport, bus lanes are a very commonly used method to improve both the travel time and the reliability of bus schedules, as they enable buses to bypass congestion and respect their schedules. Introducing segregated tracks for light rail has the same effect. Also, the prioritisation of buses and trams at traffic signalled intersections can provide a further competitive advantage, as it not only reduces schedule uncertainty, but it also results in lower travel times compared to car traffic.

The provision of information on public transport also contributes to the quality of the service, in particular with respect to the advanced information that is now provided for private transport. As such, providing real-time information to passengers at bus and tram stops, at metro and train stations, but also on board public transport vehicles gives an image of a technologically advanced public transport system, able to compete with the convenience and comfort of car travel. Information may also be provided through a website, mobile phones or TV and radio broadcasts, and may further include planned closures of lines and services, as well as the suggestion of alternative routes. Many cities now also offer so-called online "journey planners", giving travellers door-to-door directions to their desired destination.

Considering the increase of the shares of walking and cycling, similar requirements need to be met. Namely, travellers would feel more comfortable adopting these modes of travel only when their safety concerns are met, but also when the advantages of these modes become apparent. Cycling infrastructure, including tracks, lanes and designated signals, is a necessity for this, as cyclists are very often involved in accidents with road traffic when using the same carriageway. Wide pedestrian footpaths, as well as designated pedestrian areas would also enhance the walking function of streets, as they are going to convert walking into a pleasant experience, more comfortable than driving on a congested road. Various streetscape schemes, as described in Section 2, could address these issues.

Last but not least, an important element that needs to be considered in order to achieve a modal shift away from private transport is the awareness of the travellers themselves. Namely, cities should engage themselves in awareness-raising campaigns, so that the public becomes aware of the reasons why a modal shift is needed.

5 Environment and fuel efficiency

Transport emissions and noise are the primary causes of the decline in urban air quality, and their contribution is becoming more significant as car use is increasing along with increasing traffic volumes. The environmental impacts of the consumption of non-renewable energy fuels are giving rise to further concerns over the sustainability and the efficiency of current transport systems. It is therefore urgent for cities to address environmental issues in an attempt to provide better quality of life to their residents by implementing an efficient and sustainable urban transport system.

5.1 Pollution and noise

Cities and societies are increasingly concerned with environmental and sustainability issues. Pollution has become a significant problem for many urban areas, as it negatively affects the quality of life and the health of the residents. Although the chronic effects of human exposure to traffic related pollution have not been proven, the acute health effects of short term exposure have been widely demonstrated [*25*]. In addition to air pollution, the quality of life in cities is also negatively affected by noise.

In terms of air pollution, a 2008 report from the European Environment Agency (EEA) has shown that road transport remains Europe's single largest air polluter, with emissions from cars and lorries being the single most important contributor of NO_x, CO and non-methane volatile organic compounds (NMVOC) in the 27 EU member states (Figure 7). Road transport is also the second-most-important source of fine particle emissions (PM10 and PM2.5) causing breathing diseases, behind the house building sector [*26*]. A further EEA report also states that despite the overall reduction of greenhouse emissions in the EU, transport still accounts for a quarter of those and growing transport volumes have in fact increased emissions by 27% between 1990 and 2006; the need for active contribution from the transport sector is thus highlighted in order to enable the EU to meet the overall target of 20% reduction of greenhouse gases by 2020 [*27*]. The underlying conclusion on road transport is that "technology can deliver some of the greenhouse gas emissions reductions needed — but not all; behavioural changes are also needed to deliver net reductions" [*28*]. It becomes thus apparent, that air pollution caused by road transport is a major issue needing to be addressed by cities.

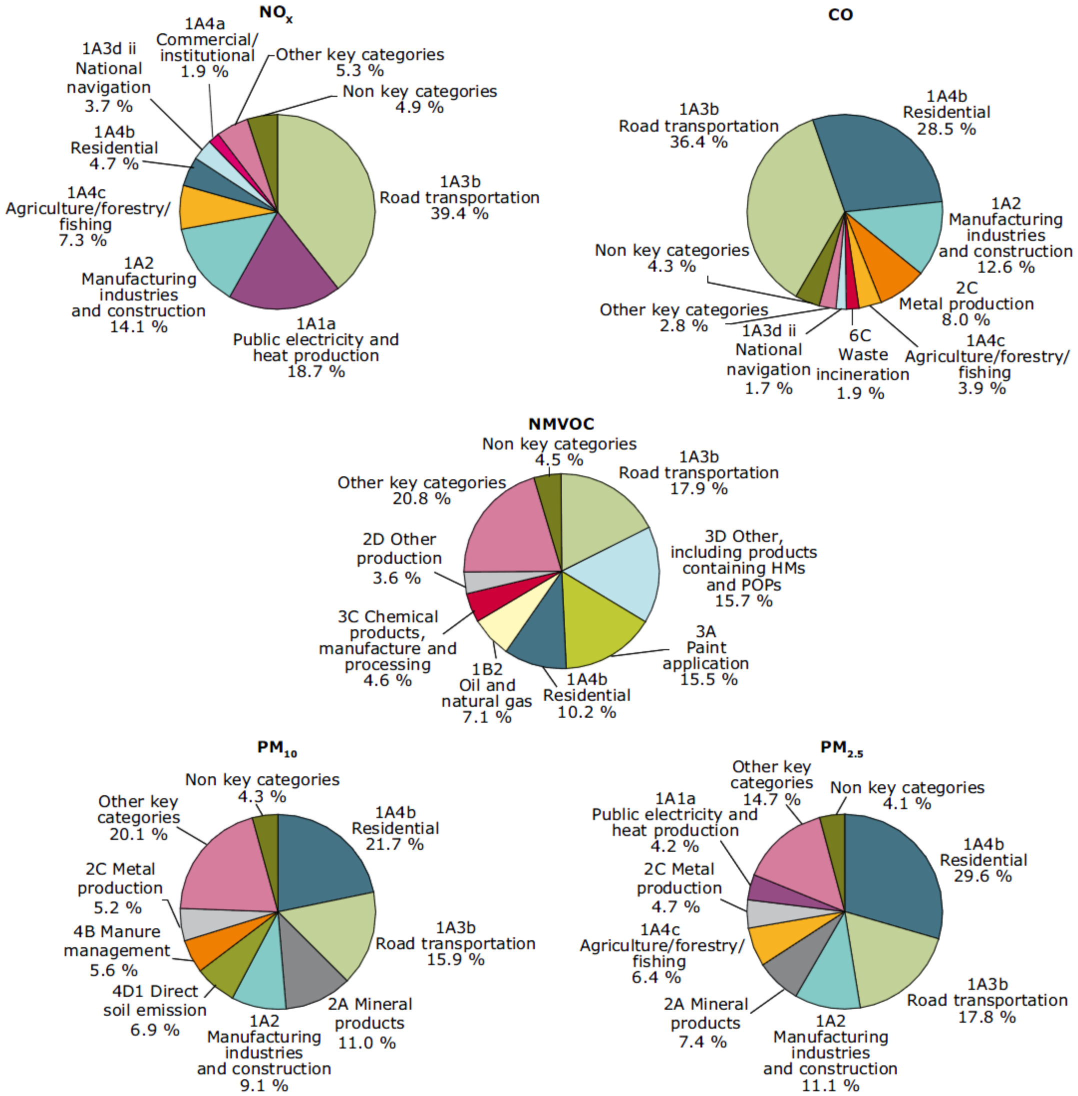

Figure 7: Air pollution sources in Europe [*26*]

Looking at noise, this hazard is often underestimated, as its impacts are considered to be less significant than those of air pollution; however, it is still a nuisance that degrades the quality of life of residents and requires to be addressed. Research has shown that many people are exposed to transport noise levels that affect their quality of life and health, notably in large agglomerations. Road traffic is by far the main source of exposure to transport noise, with almost 67 million people in the EU (i.e. 55 % of the population living in agglomerations with more than 250,000 inhabitants) being exposed to daily road noise levels exceeding the EU benchmark for excessive noise of 55 dB [*27*]. The impact of road traffic noise has, thus, far-reaching and wide-ranging effects, becoming an issue of immediate concern to many authorities.

The European Commission has introduced tight legislation for vehicle emissions of light duty vehicles, with strict standards set in terms of fine particulate matter (PM) and NO_x. It is worth noting that it is the first time a PM condition is introduced for light vehicles aiming at a PM reduction of some 80%, forcing diesel cars to install PM filters. Furthermore, the EU has been considering further stringency in the heavy vehicle standards, as these also contribute to the emissions totals. Similar legislation has also been introduced for noise.

Apart from the legislation issued by the European Commission setting standards for vehicle manufacturers in terms of emissions and noise, national authorities have also been introducing policies to ensure the use of more technologically advanced vehicles meeting the European standards. A very commonly used method to obtain a newer and more efficient car fleet is through vehicle renewal schemes that subsidise vehicle owners to scrap old vehicles and replace them with new ones. Vehicle renewal schemes are fairly popular with the public and they decrease the age of vehicle fleet; however, it is often argued that they are not an efficient way to address the environmental problem as a large public investment is required, and money could be spent more efficiently in public transport or cycling infrastructure.

At a city level, vehicle labelling policies and low emission zones and are common practices to reduce air pollution. The former, which are very popular, among others, in German cities, categorise vehicles in terms of their emissions into low, medium and high polluting. In some cases higher polluting vehicles are entirely or partially restricted, while only “cleaner” vehicles are allowed in certain areas of the city. Low emission zones, on the other hand, popular in the UK and Italy, among others, are a form of access control, as they restrict the circulation of certain vehicles, usually in historic city centres. These may be combined with charging schemes (thus setting a price to nuisance, following the “polluter pays” concept), as in the case of the London Low Emission Zone, where a daily charge is imposed on highly polluting commercial vehicles circulating in the urban area of London. Vehicles entering the zone must comply with the standards set by EU directives.

Emissions regulating policies often encourage the use of electric and hybrid vehicles. Electric vehicles store grid power in batteries, thus not contributing to urban air pollution. Furthermore, they are considerably less noisy than conventional cars and by using grid power that is produced more fuel efficiently than in cars internal combustion engines, electric vehicles consume less non-renewable fuel as well. The disadvantage of such vehicles, however, is that they still contribute to congestion, which means that they can only partially offer a solution to the transport problems, and that endorsement should be combined with the promotion of public transport, and of the sustainable modes of walking and cycling (modal shift).

5.2 Fuel efficiency

Internal combustion engines that are used in cars have been improving with technological advances, becoming more efficient in terms of fuel consumption and contributing less to air pollution. However, fuel efficiency in transport is a multidimensional environmental issue that is not only related to technological advances, but also to travel choices, driving style and network flow. Therefore, to address the issue of fuel efficiency it is required to look at improving both the efficiency of each transport mode and the efficiency of the transport system as a whole.

As cars are the main contributors to urban emissions, several studies have investigated the conditions under which cars operate more efficiently, looking into factors such as engine size, speed, etc. The most valuable finding of researchers has been that cars consume fuel more efficiently when travelling at around 65 km/h. The driving style also affects fuel efficiency, as abrupt accelerations and declarations increase fuel consumption. Therefore, considering cars at an individual level, it can be said that the most fuel-efficient driving style involves maintaining a constant speed at around 70 km/h throughout a journey. Constant travel velocity can easily be maintained on national roads and motorways/freeways; however, the velocity profile of urban journeys includes large variations, as vehicles often come to a halt at intersection traffic lights etc [*29*]. Congestion also contributes to air pollution, as cars still consume fuel while being idle or when travelling at low speeds. It is therefore in the interest of transport planners to ensure smooth uncongested flows in urban areas, as this influences vehicle emissions.

Similarly to pollution, significant environmental benefits can be achieved through congestion reduction strategies, and in particular through a modal shift from private to public transport and through the promotion of fuel-efficient and sustainable modes of travel. Public transport is considerably more efficient in terms of fuel consumption per traveller than private cars, not only because of its higher passenger occupancy, but also because it keeps large numbers of vehicles off the road, thus relieving the network from congestion and ensuring steadier traffic flow conditions. Similar effects on fuel efficiency has the promotion of walking and cycling, which substitute motorised trips and hence reduce fuel consumption, as well as the endorsement of “clean” vehicle technologies (e.g. electric vehicles, hybrid etc), which are energy efficient but do still contribute to congestion.

6 Other problems

Although many urban transport problems fall under the categories discussed in the previous sections, there are also further problems, different in nature and smaller in scale that can only be defined at their own context. These mainly include political difficulties, safety and economic prosperity.

6.1 Political difficulties

As in any other discipline, transport is also related with a number of political issues to be addressed for a policy, a scheme or an infrastructure project to be implemented. These can be broadly categorised into two categories: conflicts of interest and communication problems.

Conflicts of interest arise between elected politicians (mayors, ministers, etc.) and the public (voters), as the latter expect to see solutions to the cities' transport problems during the politicians' terms. The characterisation of a politician as "successful" (and his/her re-election) strongly depends on the voters' opinion. As such, politicians often look to satisfy the short-term wishes of the public to ensure the overall happiness of the voters, and therefore tend to support short-term plans of uncertain effectiveness, disregarding long-term impacts and sustainability issues. For example, it is often argued that vehicle renewal schemes are a policy commonly supported by politicians due to its large public acceptance, disregarding alternative solutions that could utilise funds in better ways. To overcome such political implications, the establishment of evaluation techniques and performance indicators of transport policies is required, as it is currently very difficult to demonstrate the long-term benefits of a scheme, and convince the public about them.

Considering communication problems, the management of traffic in cities involves several processes such as monitoring, dynamic management and enforcement, and it is very often the case that different authorities are responsible for each one of them. Namely, in most cities at least three or four authorities are involved in traffic management, with the most common being national, local and city authorities and the police, but also being complemented by parent companies, public-private-partnerships and public funding initiatives. Good communication and coordination between those is, as expected, a necessity for any efficient traffic management process. However, it is often the case that there is lack of communication between authorities in the same city, particularly when different authorities manage different parts of the road network. The impact can be felt in many aspects of traffic management, such as, for example, incident and emergency response, where it is essential to have a mechanism in place, which detects an accident, alerts the emergency services, informs the public and re-routes traffic where necessary. The communication between authorities has not been looked at in the literature so far, but it is clear that cities would benefit from a common evaluation framework in this field.

6.2 Safety

The loss of human life has been an important issue since the early development of the transport sector. It is well established that there are several factors affecting the road fatality rate of any country, the most obvious among them being the speed, the level of vehicle ownership, the condition of the infrastructure and the condition of the vehicles. The drivers' attitude is also mentioned as an important factor, though it is very difficult to evaluate [*30*]. Furthermore, several countries have defined acceptable limits and set future goals in order to secure the health, safety and welfare of all road users.

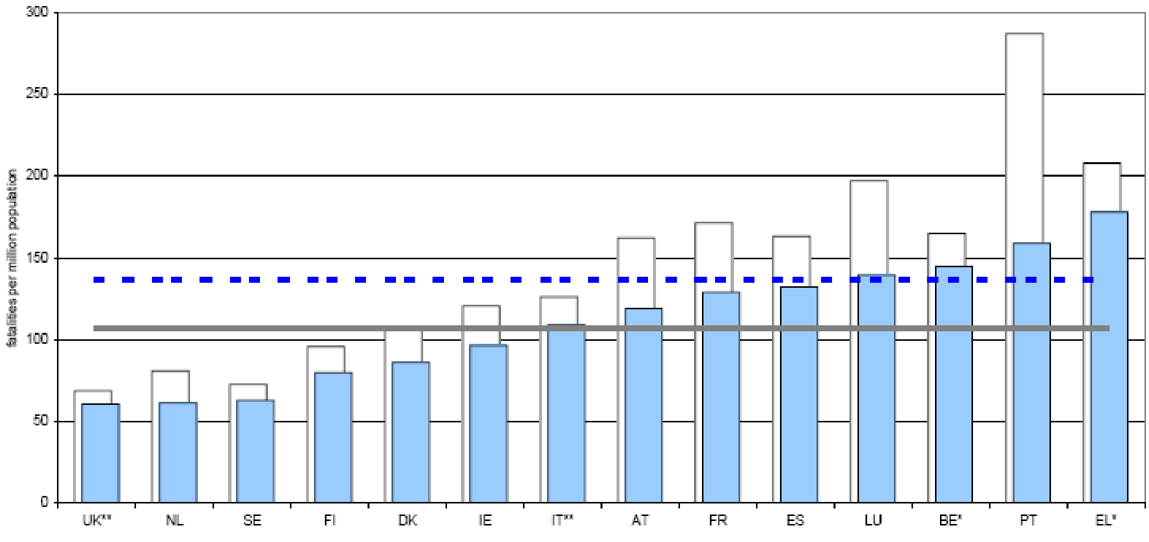

Figure 8: European fatality rates change between 1993 (white) and 2002 (blue) (per million inhabitants) [*31*]

Figure 8 illustrates the fatality rates of European countries over the period 1993 to 2002. The white columns illustrate 1993 figures, the blue columns show 2002 figures, the dashed line indicates the 1993 average, and the continuous line shows the 2003 average. Although the reduction in fatality rates over the past years is obvious, transport safety remains an important problem faced by cities.

Much work has been done on quantifying the effects of various measures on traffic safety, with accident numbers being the sole measure. In fact, traffic safety has been studied extensively, and a reduction in accidents is on every transport political agenda. Some countries have even set a zero-fatality target in the long run (e.g. Sweden). It is important to note, though, that traffic safety is a sensitive topic, and that accident numbers can be easily manipulated in order to deduce different conclusions. For example, a reduction in accidents following the implementation of a new traffic engineering scheme may be considered and presented as a success by the supporters of the scheme; however, the opponents of the scheme may interpret them in a different way, claiming that the reduction is a result of an overall reduction in accidents and not a consequence of the scheme in question. It is clear that an evaluation framework to assess the impacts of traffic management schemes in terms of traffic safety is needed.

6.3 Economic prosperity

One of the fundamental reasons for the existence of cities is proximity, as several economic advantages are related to short trip distances and travel times. Urban transport problems, such as congestion, can increase travel times and affect the efficiency of commerce, counterbalancing the economic advantages of urban proximity. From an economic perspective the existence of nearby urban areas establishes a competitive environment, in which each city tries to provide better transport services to residents, businesses and industries in order to advance, expand and ensure the economic prosperity of the region.

Congestion and increased travel times prompt businesses and industries to look for alternatives and often to move to areas that do not face similar problems. Although, this “competition” between cities has a positive effect, as cities try to continuously improve their services to become more competitive, it becomes a constraint when dealing with sustainability issues. This is because many cities (especially those who are private-transport-oriented) are reluctant to move towards sustainability and public transport, as they fear an increase in travel times with a decrease in the perceived comfort of the travellers, which can potentially harm the economic prosperity of the city. Being able to evaluate the impacts of such a move on economic prosperity would be very useful.

7 The role of Intelligent Transport Systems

Recent technological developments and ITS have made possible the development and implementation of a wide range of traffic management techniques, methods and policies. The blend of ITS, computing and communications technologies have contributed in improving the safety, efficiency, and convenience of road transport, both for people and for goods. The establishment of ITS is visible today, as roads are equipped with electronic tolling and VMS; passenger vehicles have navigation systems and emergency notification systems; and public transport vehicles have location and communication systems. Transport infrastructure in cities has also improved through systems automatically tracking, monitoring and supporting the better management of road traffic. This wide variety of fields and applications confirms that ITS have gained widespread acceptance within the transport community and by the general public. In fact, many cities already use ITS fairly extensively, while increasingly more plan to do so in the next years.

The main technologies that have so far been utilised for transport purposes are wireless communications, computational technologies, floating car data, sensing technologies, inductive loop detection and video vehicle detection technologies. The robustness of the technologies used offers great flexibility to ITS, which is one of their major advantages, as cities have the ability to tailor a method or a system to fit their individual needs and future plans. The three main fields ITS have contributed to are: congestion management; safety and enforcement applications; and information provision.

In terms of congestion management, common example ITS applications include:

- electronic toll collection, that makes it possible for vehicles to drive through toll gates at traffic speed, reducing collection and automating toll collection,
- zones with urban road pricing, that collect a charge form vehicles entering the zone using electronic toll collection and automatic plate recognition,
- variable speed limits, that assist in the management of traffic by reducing the congestion build-up rate,

In terms of road safety and enforcement, ITS have applications such as:

- intelligent speed adaptation that warns or prevents drivers from exceeding the local speed limit
- automatic road enforcement, that by using cameras and sensors can identify vehicles disobeying rules. Some examples are red light cameras, bus lane cameras and speed cameras
- emergency vehicle notification systems that can generate emergency calls either manually or automatically using in-vehicle sensors.
- collision avoidance systems that notify drivers about stalled vehicles and traffic incidents on their route.

Finally, in terms of information provision, example ITS applications include, among others:

- the provision of real-time traffic information through various means, such as VMS, mobile phones, radio etc
- the supply of anticipated travel times, as well as personalised route guidance through satellite navigation systems and mobile phones

The number of ITS applications is continuously rising with new technological developments providing a wide range of methods and systems for traffic management. However, the orientation of ITS technologies so far has primarily been towards the efficient management of private transport and the smoothening of road traffic, with less focus on public transport. ITS solutions mainly focus on improving road traffic conditions in cities in favour of cars, therefore providing a competitive advantage to private transport in terms of modal choice. As mentioned earlier in this report, the cities' main concern is a modal shift from private transport to more sustainable modes, and in particular public transport, indicating that ITS should provide solutions and contribute to the management of public transport as well. This will balance the quality of service provided by public transport, establishing a more competitive environment [*32*].

ITS can help manage different modes of transport through signal phasing and lane control measures. Furthermore, on-trip information and provision of multi-modal journey planning support the delivery of better public transport systems. So far a limited number of ITS applications are oriented towards public transport, with the most representative being:

- traffic signals programmed to prioritise public transport. Applications so far have demonstrated public transport travel time reductions of 10-15% without observable delays to private transport
- bus location data used to provide real-time public transport information at bus stops and to improve travel information services

- demand-responsive systems, such as booking journeys on a door-to-door bus service

Although public-transport-oriented ITS are yet to gain the acceptance their private-transport-oriented counterparts have achieved, ITS have already contributed to transport integration. Smart ticketing practices that allow the use of cards or electronic fares on both public services and parking facilities encourage integration between private and public transport. Ticket integration encourages a simpler, user friendly and cost-effective ticketing process for public transport users by allowing the use of a single ticket through a journey irrespective of operator.

Overall, ITS have contributed to road management and safety, travel and traveller information, efficient road freight, environmental impacts, emergency planning and public and private transport integration. To ensure future development, the benefits and operation of ITS must be clear to the network users, and their costs should be justified against a wide array of competing solutions including infrastructure investments. To achieve this, reliability, ease of use and affordability issues require to be addressed, as they are crucial ingredients for gaining public acceptance.

8 Conclusions

The close relationship between transport and economic prosperity, which justifies the existence of cities, has been identified. However, what was once considered an advantage, known as "economies of agglomeration", is now often considered a drawback, as in many cities the existing transport infrastructure cannot cope with the continuously increasing demand. The continuous rise of urban population has rendered many transport systems obsolete, which affects not only the economic aspects of city life, but also the quality of life of the residents. City transport planning authorities face a number of problems today, which result from their objective of providing efficient transport while at the same time ensuring sustainability and a high standard of living.

The transport problems that cities are faced with can be broadly categorised in five areas: land use; congestion; car dependence; environment; and other issues, which include safety, political difficulties and economic prosperity. These problems are naturally interrelated, and it is very likely that the isolated treatment of a single problem without consideration to the others will give rise to additional issues. As such, a holistic approach is required for their solution, using a methodological framework that can address urban transport problems with simultaneous consideration of all the problem areas.

Despite cities having their own characteristics and individualities, and as a result facing some unique problems only specific to them, it can be concluded from this study that many of the problems they face are common. For example, the vast majority of the city authorities have stated that their primary objective is a modal shift away from private transport to more sustainable modes, such as public transport, walking and cycling. Most cities have taken or plan to take action to address this objective, along with their further short- and long-term objectives, which include reducing emissions, decreasing road accidents, etc. In addition, ITS seem to play an important role in urban traffic management, as cities place them fairly high in their priorities. They are generally considered as offering potential solutions to many of the cities' problems, with the vast majority of the cities having implemented ITS technologies at least in terms of providing information to the public and facilitating traffic management, or planning to do so in the coming years.

City transport planning authorities could greatly benefit from strategies and policies implemented elsewhere around the world, as based on the results, they could identify best practice and tailor it to their city-specific needs. However, each city at the moment tends to be autonomous and act in response to its own political pressures, making it very difficult to build a picture of how transport policies are being used to provide solutions, the scale of deployment, and the comparative effectiveness of that deployment. In several cases cities just follow the practice established in the country they are in, without considering whether this practice is suitable for their own specific needs, and as such often have to face unconvincing results. The development of a common evaluation framework can assist in overcoming this issue.

Key Performance Indicators (KPIs) can help to understand in which areas the transport network of a city is performing well. KPIs should include all areas in which traffic management applications can improve performance (such as safety, efficiency of individual modes, sustainability, social inclusion etc) so as to show whether recent investments in the transport network have brought improvements and to assist transport planners in making business cases for future investments. KPIs will further identify possible markets for urban traffic management applications by looking at the potential for implementing recent technological advances through targeted case studies that are of interest to cities. Establishing such performance indicators by setting up and utilising a coordinated network of city partners is the ultimate objective of the CONDUITS project.

References

[*1*] Banister D. *Transport and Urban Development*, E & FN Spon, London, 1995.

[*2*] Small KA and Verhoef ET. *The economics of urban transportation*, 2007.

[*3*] Barnes, G. The importance of trip destination in determining transit share. *Journal of Public Transportation*, Vol. 8, 2005, pp. 1-15.

[*4*] Newman PWG and Kenworthy JR. *Cities and automobile dependence: an international sourcebook*, Gower, Brookfield, VT, 1989.

[*5*] Cervero, Robert and Wu, Kang-Li. *Subcentering and commuting: evidence from the San Francisco Bay area, 1980-1990*. 1996.

[*6*] Schwanen, T, Dijst, M and Dieleman, FM. Polices for urban form and their impact on travel: the netherlands experience. *Urban Studies*, Vol. 41, 2004, pp. 579-603.

[*7*] Keyes, DL. Energy for travel: the influence of urban development patterns. *Transportation Research Part A*, Vol. 16, 1982, pp. 65-70.

[*8*] Gordon, P, Kumar, A and Richardson, HW. The influence of metropolitan spatial structure on commuting time. *Journal of Urban Economics*, Vol. 26, 1989, pp. 138-151.

[*9*] Bento, AM, Cropper, ML, Mobarak, AM and Vinha, K. The effects of urban spatial structure on travel demand in the United States. *The Review of Economics and Statistics*, Vol. 87, 2005, pp. 466-478.

[*10*] Crane, R. The influence of urban for on travel: An interpretive review. *Journal of Planning Literature*, Vol. 15, 2000, pp. 3-23.

[*11*] Buchanan C, Cooper GHC, MacEwen A, Crompton DH, Crow G, Michell G et al. *Traffic in towns*, HMSO, 1963.

[12] Jones P, Boujenko N and Marshall S. *Link & Place: A Guide to Street Planning and Design*, Landon Publishing, London, UK, 2008.

[13] Hamilton-Baillie, B. Urban design: Why don't we do it in the road. *Journal of Urban Technology*, Vol. 11, 2004, pp. 43-62.

[14] Hamilton-Baillie, B and Jones, P. Improving traffic behaviour and safety through urban design. *Proceedings of the Institution of Civil Engineers - Civil Engineering*, Vol. 158, 2005, pp. 39-47.

[15] Arnott, R and Small, KA. The economics of traffic congestion: Rush hour driving strategies that maximize an individual driver's convenience may contribute to overall congestion. *American Scientist*, Vol. 82, 1994, pp. 446-455.

[16] Smeed, RJ. The traffic problem in towns: A review of possible long term solutions. *The town planning review*, Vol. 35, 1964, pp. 133-158.

[17] UK Department for Transport. *Transport Trends*, National Statistics, 2005.

[18] Rodrigue, J-P, Comtois, C and Slack, B. Transportation and spatial cycles: evidence from maritime systems. *Journal of Transport Geography*, Vol. 5, 1997, pp. 87-98.

[19] Shoup, DC. The trouble with minimum parking requirements. *Transportation Research Part A*, Vol. 33, 1999, pp. 549-574.

[20] European Foundation for the Improvement of Living and Working Conditions (Eurofound). 2009 *Official website:* http://www.eurofound.europa.eu/areas/qualityoflife/eurlife/index.php?template=3&radioindic=105&idDomain=9.

[21] Rodrigue J-P, Comtois C and Slack B. *The Geography of Transport Systems*, Routledge, New York, 2006.

[22] Eurostat. *Europe in figures: Eurostat yearbook 2009*. 2009.

[23] Kaparias, I., Zavitsas, K., and Bell, M. G. H. *State-of-the-art of urban traffic management policies and technologies - CONDUITS Deliverable 1.2-1.3*. 2010.

[*24*] Paulley, N, Balcombe, R, Mackett, R, Titheridge, H, Preston, J, Wardman, M, Shires, J and White, P. The demand for public transport: The effects of fares, quality of service, income and car ownership. *Transport Policy*, Vol. 13, 2006, pp. 295-306.

[*25*] Briggs, D, de Hoogh, C, Gulliver, J, Wills, J, Elliott, P, Kingham, S and Smallbone, K. A regression-based method for mapping traffic-related air pollution: application and testing in four contrasting urban environments. *The Science of the Total Environment*, Vol. 253, 2000, pp. 151-167.

[*26*] European Environment Agency. *Annual European Community LRTAP Convention emission inventory report 1990-2006*. Technical report No 7/2008, 2008.

[*27*] European Environment Agency. *Transport at a crossroads. TERM 2008: indicators tracking transport and environment in the European Union*. EEA Report No 3/2009, 2009.

[*28*] European Environment Agency. *Climate for a transport change. TERM 2007: indicators tracking transport and environment in the European Union*. EEA Report No 1/2008, 2008.

[*29*] Chang, DJ and Morok, EK. Vehicle speed profiles to minimize work and fuel consumption. *Journal of Transportation Engineering*, Vol. 131, 2005, pp. 173-182.

[*30*] Bester, C. Explaining national road fatalities. *Accident Analysis and Prevention*, Vol. 33, 2001, pp. 663-672.

[*31*] European Comission. *Annual Statistics Report 2004*. 2004.

[*32*] UK Department for Transport. *Intelligent Transport Systems - The policy framework for the roads sector*. 2005.