Archives of
Transport System
Telematics

Volume 2

Issue 3

September 2009

Externalities and their influence on safety

A. KALAŠOVÁ
University of Zilina, Faculty of Operation and Economics of Transport and Communications, Department of Road and Urban Transport , Univerzitná 1, 010 26 Žilina, Slovakia
EMAIL: alica.kalasova@fpedas.uniza.sk

ABSTRACT
Effective operation of transport depends on the correct costs fixing. The external cost – externality- is the cost or its part that disinterest its author but interests the other people who are not participating in it or who are its victims. Some externalities cannot be expressed in numbers, like the death, human suffering and damage of environment. Externalities interfere with effective division of resources within sectors. According to the study of EU, the road transport, with its 92%, is the biggest contributor to externalities..

KEYWORDS: Intelligent Transport System, Traffic Flow Theory safety

1. Introduction

One of the most significant factors affecting the increase in road transport safety is the reduction of external costs. External costs are described as follows.

When consumers decide to purchase an item or take a trip, they examine the price of a given option and compare it to the gain or satisfaction they expect to derive from the item or trip. For instance, an individual wishing to get from A to B will consider the price (of using public transport or his/her private car) and quality of the service provided before opting for a given transport mode. Users are willing to accommodate a whole array of parameters (speed, frequent/regular service, quality, flexibility, etc.) in the transport price they pay.

Conversely, consumers of goods or services do not generally foot the full bill for the costs their decision imposes on society and the environment. Such costs are defined as external, because they are not reflected in the price paid by users and are not the factors in the market. The main sources of external cost in the transport sector are accidents, congestion, air pollution, noise and climate change. Individuals using a given form of transport are not generally aware of the external cost generated and indeed it is possible that some of these costs have never been defined.

Nonetheless, external costs do exist and since they are not met by the parties responsible, they must be borne by society as a whole. [1] Significant external costs are:

- Accidents; when transport systems are used, accidents occur, generating a whole range of costs which are only partly covered by mutual risk insurance schemes (loss of life, medical care and disabilities sustained by victims, loss of production, etc.),
- Air pollution, emission of particulate matter, carbon monoxide, lead, volatile organic compounds, nitrogen oxides and sulphur dioxide, damaging health, the environment and buildings,
- Climate change; greenhouse gases (mainly carbon dioxide – CO_2) have an enduring impact on the earth's climate, resulting in increased desertification, raised sea levels, serious harm to agriculture and other destructive environmental and health-related side-effect,
- Noise; transport generates noise, which adversely affects humans in a variety of ways, causing disturbances, stress and more serious health problems,

- Congestion, more vehicles are being added to already dense traffic flows, particularly car traffic flows, paralyzing the system and leading to substantial wastage for all users. Congestion makes the entire transport system inefficient.

2. Impact of congestions on safety

An individual highway crash is a rare, random, multifactor event, preceded by a situation in which one or more persons failed to cope with their environment. In the aggregate, however, traffic crashes are quite numerous and often follow certain patterns that can be identified. Crashes reflect a shortcoming in one or more components of the driver-vehicle-roadway system. It is therefore very important for freeway practitioners to monitor traffic collision experience, and to use this information to identify, plan, implement, and evaluate corrective actions. Numerous approaches exist for improving safety and reducing crashes on highways. Many of these are beyond the scope of freeway management and operations, per se (e.g., enforcing seat belt laws, in-vehicle crash-avoidance technologies, geometric realignment); but others – such as improved signing and lighting, skid resistance pavement, adding shoulders and auxiliary lanes, and removing obstacles – are well within the realm of "operations".

As previously noted, a major goal of freeway management and operations is to reduce congestion; and a reduction in congestion may also enhance safety. But how does congestion affect highway safety? The basic theory behind the interaction is that congestion leads to higher vehicle densities (i.e., more closely spaced vehicles on a roadway), which provides more opportunities for conflict. Congestion also reduces vehicle speeds, which implies that when vehicles are engaged in a crash, the collision forces are lower, thus reducing the injury to occupants. Another aspect of the model is the concept of "secondary" crashes—crashes that occur due to conditions produced by an existing crash. Some of these conditions—which wouldn't exist without the occurrence of the first crash—include rapid backward queue formation (as vehicles suddenly stop to avoid the first crash), rubbernecking by drivers, and the maneuvers of emergency vehicles. Finally, the flow restrictions produced by crashes worsen existing congestion.

The details of the relationship between congestion and safety are not well understood (with the exception of lower crash severities, which have been documented in a general way for congested conditions, and the associated lower speeds). Based on the limited work that has been performed, a few tentative conclusions may be drawn:

Crash potential probably increases as congestion increases.

There is a lower proportion of single vehicle crashes (e.g., run-off-road, rollover, collision with fixed object) during congested conditions and a higher proportion of multiple vehicle crashes.

Crash severities (extent and nature of personal injuries) are lower during congested conditions, due to lower vehicle speeds at the moment of crash impact.

In general, it can be assumed that any operational improvement that reduces congestion will lead to fewer crashes. The severity of crashes that occur will be higher, however, and it is likely that a greater proportion will be single vehicle crashes. Knowing these facts can target mitigation strategies to single vehicle crashes and higher severities—such as wider roadside recovery zones, protection of highway "furniture," and coordination with emergency medical services. Moreover, an operations philosophy must take a systems-oriented view, where the consequences of a specific action (e.g., flow improvements) consider linked impacts such as safety.

3. Traffic flow theory

The generalized relationships between speed, density and flow rate are shown in Figure 1, with these parameters defined as follows: [1]

- Flow Rate (M) – the equivalent hourly rate (vehicles per hour) at which vehicles pass over a given point or section of a lane or roadway during a given time interval of less than one hour,
- Speed (V) – defined as a rate of motion expressed as distance per unit of time, generally as kilometers per hour (km/h). In characterizing the speed of a traffic stream, a representative value must be used, because

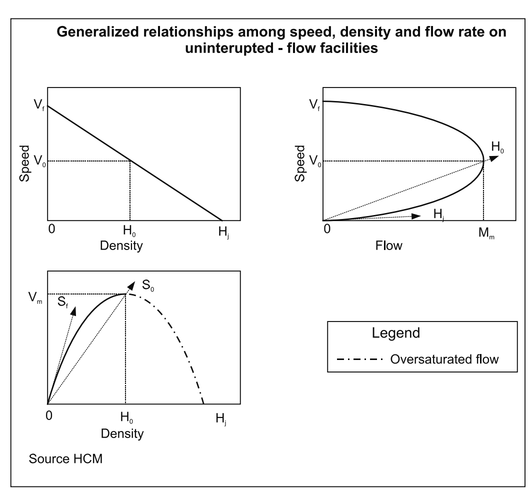

Fig.1. Basic traffic service

a broad distribution of individual speeds is observable in the traffic stream. The curves in Figure 1 utilize "average travel speed", which is computed by dividing the length of the highway segment under consideration by the average travel time of the vehicles traversing it,

- Density (H) – the number of vehicles occupying a given length of a lane or roadway at a particular instant. For the curves shown in Figure 1 density is averaged over time and is usually expressed as vehicles per kilometer (veh/km),

The principles of macroscopic models are relations between the essential characteristics of a traffic flow – intensity (M), density (H) (quantitative characteristics) and speed (V) (a qualitative characteristic). For a complete description only two of these characteristics are sufficient, the third one can be calculated according to a continuity equation: $M = H.V$

4. Resolving congestions using Intelligent Transportation Systems

One of the possible ways of increasing safety is to provide the participants of traffic with information in advance. Conditions for steady and safe traffic are made this way. Intelligent transport systems - ITS are able to give us this possibility. Basic aim of ITS is to: [3] increase safety of road transport, increase efficiency of transport represented by cut down transport time, increase quality of environment and improve commercial productivity of a company.

ITS are systems which help to make efficient use of road and urban communication network, using information, communication and directing technologies. They make basic conditions for high quality communication and information society that we are approaching also in our conditions.

Intelligent Transportation Systems (ITS) is the application of advanced electronics, computer, communications, and sensor technologies – in an integrated manner – to increase the efficiency and safety of the surface transportation network. ITS encompasses technologies that can lead to: [2]

- Better management and operations of the existing highway, public transportation and railroad infrastructure to ease congestion and respond to crises.
- Safer and more convenient travel for people.
- More efficient and secure freight movements.

5. Traffic characteristics of the city of Žilina

Žilina is surrounded by four entry points to the city. It is the main artery heading from the East (Kosice direction) towards the West (Bratislava direction), the northern entry from the direction of Poland and the southern entry from the direction of Prievidza (fig.2). Žilina county is an important transport crossroad. Important international roads leading through the Kysuce region to the Czech Republic and Poland origin in Žilina. There is also a public international airport near Dolny Hricov.

Recently, the problems of increasing externalities have been causing difficulties in transportation within Žilina city. The city of Žilina is the fastest-development region in Slovakia.

Žilina is the largest city situated on the Váh river, located 49°15´ of northern latitude and 18°45´ of eastern longitude. With population of 85 425 inhabitants (on 1st January 2007) and the area of 80,03 square kilometers it creates an important centre of northwest Slovakia.

As in other European cities, the traffic situation in Žilina is continually getting worse. Fast grow of individual transportation, descent of public transport together with development of new business and commercial activities in the city – all these processes make an important impact on the city communication system. There are about 62 550 registered cars (on 31th 12. 2008) in the Žilina county (fig. 3), the level of motorization is about 397 cars per 1000 inhabitants, the level of automobilization is about 286 cars per 1000 inhabitants.

The problem we deal with lies in the central part of the city where congestions and problems with parking irritate more and more people. Every year, Faculty of Operation and Economics of Transportation and Communications realizes a survey of traffic intensities on selected crossroads in Žilina. Results of these surveys, together with data gathered from several bachelor and diploma theses related to organization of traffic in the city, give us an opportunity to have a relatively detailed overview of traffic situation in Žilina within last 15 years. Based on the gathered data, we can see an unanimous increase of traffic intensities in covered area. The growth between years 1994 and 2006 reached up to 28 % on one of the monitored crossroads.

The growing traffic brings another related problems. The number of traffic accidents in Žilina county is rising. On the other side, the utilization of public transport has dropped rapidly. It is apparent that meeting the increasing demand is not possible through ever increasing capacity of road system. Such solution eventually leads to a higher share of individual car transport compared to the lower (and disadvantageous) share of public transport means

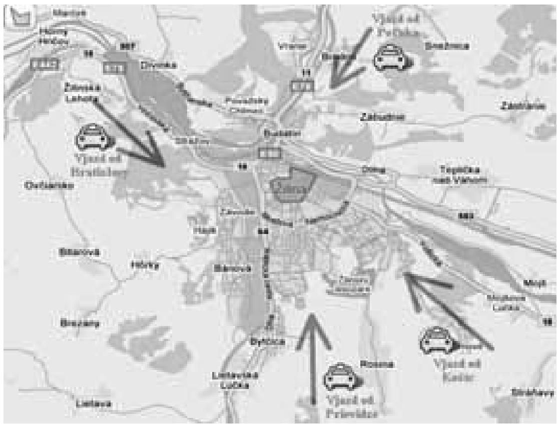

Fig.2. Individual entry points to Zilina

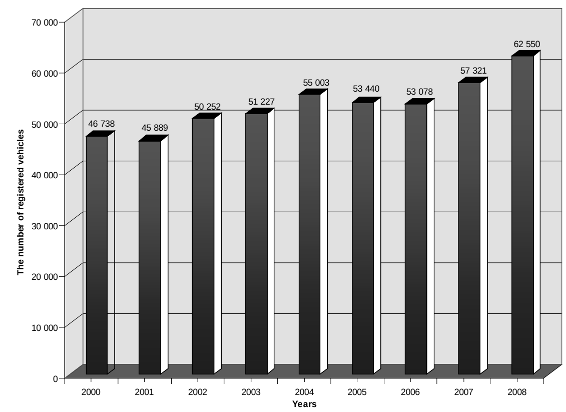

Fig.3. Number of registered vehicles

which in Žilina is provided by the DPMZ company. There has been a dangerous trend in decreasing demand for public transport in the recent years. Table 1 provides the evidence for this in terms of decreasing number of passengers. As the statistics provided by Transport Company of the City of Žilina shows, there is a 47 % dropdown in passengers transported annually in last 8 years (table 2) [3]. There are several reasons of this problem, inter alia insufficient financing of public transport and thus reduction of lines, disastrous organization of trolleybus network and at last but not least congestions that affect public transportation and make it unreliable. The increase of individual car transport is caused by various factors, e.g. the increase of total length of roads within the city which is presumably linked to business development, changing citizens' lifestyle, the increase of car number in possession of citizens etc.

6. Conclusion

Negative externalities disrupt the effective share of resources. This brings about two contradictions: the society demands higher mobility but is ever less tolerant towards the increase of externalities. Efficient transport is therefore underlined by a proper calculation of costs. Lessons learnt show that investments into infrastructure only attract more cars, so external costs do not decrease and problems cannot be basically solved via new transport infrastructure. One of the positive ways of easing the impact of the problems is the application of ITS technologies that are a tight connection of information and communication technologies with vehicles and transport networks that move people and items, and thus help improving every part of the transport chain. One of the possible solutions in Zilina is the establishment of electronic toll system which is a modern ITS solution. It gathers information on transport network, traffic, vehicles and users. It constitutes an information and communication basis for the provision of above-standard telematic services. It allows for a development of telematic, safety and information services (real-time traffic information, localization, traffic density and travel time information etc.) Apart from the improvement of transport situation in the city, the improvement of regular maintenance and reconstruction of existing road network can be possible thanks to the acquired finances. These can also secure the development of transport infrastructure at required level or the improvement of transport systems.

Table 2. Utilization of public transport in Žilina

Year	Number of passengers
2001	24 552 137
2002	23 283 584
2003	19 334 019
2004	17 281 517
2005	15 616 869
2006	14 666 257
2007	14 348 825
2008	13 224 155

Elaborated on the basis of Grant VEGA 1/0398/08 Negative externality reduction in road transportation

Bibliography

[1] KALAŠOVÁ, A.., STACHO, M.: Decrease in congestions is one of The most important factors for increase in safety in road transport .In: Modern Safety Technologies in Transportation 2005, Košice, ISBN 80-969106-1-2

[2] KŘIVDA, V., et al.: Transport Telematics. Published by EDIS ŽU in Žilina, 2009, ISBN 978-80-8070-981-5

[3] Dopravný podnik mesta Žiliny (Transport enterprise of Zielina), http://www.dpmz.sk,