Abstract: Extension of European Union causes increase of free transfer of people and goods. At the same time they raised the problems associated with the transport, e.g. congestion and related accidents on roads, air traffic delays and more. To increase the efficiency and safety of transport, the European Commission supports the introduction of intelligent transport systems and services in all transport sectors. Implementation of intelligent transport systems and services in the road transport reduces accident frequency, increases the capacity of existing infrastructure and reduces congestions. Use of toll systems provides resources needed for the construction and operation of a new road network, improves public transport, cycling transport and walking transport, and also their multimodal integration with individual car transport.

Keywords: transport, management, traffic flow

1 Introduction

Systematic investigation of regularities of transport systems is currently a very extended scientific activity [1–4]. Motivation for research realization is possible to find in an effort to create functional transport models and by them to optimize real transport situations. While most present studies deal with the so-called macroscopic models being based on fluid dynamics, some of the most recent studies approach the issue on a microscopic level i.e. by simulating single vehicles and their interaction. These models use for description thermodynamic physics, so these models present traffic stream as a particle gas allocated in the thermal bath with specific temperature. Both afore said approaches, i.e. macroscopic and microscopic, present clear idea about the ways of transport system operation and its important characteristics.

The intelligent transport systems (ITS) solving some problems of transport systems. These intelligent systems represent an interconnection of new information and telecommunications technologies and management systems for vehicles and infrastructure networks. Future of transport is inextricably linked to intelligent transport systems. Generally speaking, it is a system for managing and directing traffic, solutions its safety and flow of traffic. The issue of intelligent transport systems has a relatively wide range in both the spectrum of services offered, as well as the possibilities of its usage, ITS provides a comprehensive view of the transport systems. The aim of the use of ITS is more efficient functioning of transport systems, improve safety, increase productivity and economic efficiency of transport and contribute to improving the environment.

2 Methods

2.1 Related transport characteristics

The best-known knowledge about management of road transport is the fact that the dependence of the number of vehicles passing the set point depends on the density of traffic and it exhibits strong saturation [5–7]. For densities to 20 vehicles per kilometer increases the traffic linearly, while for higher densities this dependence has radical decrease to the field with formed unpopular congestions (about 70 vehicles per kilometer). At the same time the hysteretic nature of the fundamental diagram is mainly caused by the human factor, i.e. increase of psychological stress of the driver when in traffic congestion is no longer possible to safely

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move in high speed. The frustration effect is so strongly reflected also in car traffic which produces a range of adverse effects [11–16]. Globally, all reasons for creation of transport non-linearity (saturation conditions and congestions) are concealed inside the human brain.

### 2.2 Basic parameters of the traffic flow

The state of the traffic flow in the point $x$ and in time $t$ is described by three basic parameters:

- **density of the traffic flow** $\rho(x,t)$ (number of vehicles for length unit – usually per kilometer),
- **speed** $u(x,t)$ (in km.h$^{-1}$)
- **intensity of the traffic flow** $q(x,t)$ (number of vehicles which passing by the profile per time – usually per hour).

Mathematical description of the relation among these three parameters is the base equation of the theory of traffic flow.

By stabilized traffic flow:

$$q = u \cdot \rho$$  \hspace{1cm} (1)

The speed of traffic flow is dependent on the density of the traffic flow:

$$u = u(\rho)$$ \hspace{1cm} (2)

By settlement:

$$q(\rho) = u(\rho) \cdot \rho$$ \hspace{1cm} (3)

In addition to this basic dependence, the transport flow depends on many other factors, i.e. design parameters of the road, its current state, weather, daily, weekly, or yearly period, etc. The other parameters are also vehicles, for example type and state of the vehicle, personal characteristics, driver, and various random events. According to the aforesaid description of the transport flow this means that the equation (2) is changed by the conditions, i.e. the dependence of traffic flow speed on the density. For the traffic flow, it is possible to apply the law of continuity, which can be characterized as an act to maintain the number of transport flow on the density, and it is possible to express by the equation:

$$\delta_t \rho + \delta_x [u(\rho, x, t) \rho] = 0$$ \hspace{1cm} (4)

Where $x$ presents space and $t$ presents time variable. The function $p(x,t)$ is the density of vehicles and $u(p,x,t)$ is their speed. The act about preservation of the number of vehicles is possible to present in the integral form:

$$d/dt \int_{x_1}^{x_2} p(x,t) dx + v(x_2,t) - v(x_1,t)p(x_1,t) = 0$$ \hspace{1cm} (5)

This equation is possible to interpret as follows: the time change of the number of vehicles in the reporting period from the point $x_1$ to the point $x_2$ is the difference between the number of vehicles which enter to the monitored area by the point $x_1$ and the number of vehicles which leave the area in the point $x_2$ [1].

### 3 Results

An integrated system for safer and more efficient transport which at the moment works as an integrating mechanism for the interoperation of drivers, vehicles and roads is an intelligent transport system (ITS) that includes:

- systems of information for passengers (ATIS - Advanced Traveller Information Systems),
- systems of vehicle park management (AFMS - Advanced Fleet Management Systems),
- systems for traffic management (ATMS - Advanced Traffic Management Systems),
- systems for vehicle management (AVCS - Advanced Vehicle Control Systems),
- systems of mobile travelling devices (AMSS - Advanced Mobile Support Systems).

The main advantages of intelligent systems and services implementation on the part of ITS are:

- increase of traffic and operation safety,
- increase of operational and traffic capacity,
- improved services for public on the part of increase of mobility and comfort of travelling,
- favorable economic effects arising from fluency of transport,
- implementation of central management increases effectivity of financial sources utilization,
- implementation to the concept of transport within the frame of European structures,
- impact on the environment – decrease of emissions,
- development of the region.

#### 3.1 Information systems for passengers (ATIS)

Systems provide information for passengers and assure effective and safe transportation. By the fact that information are provided before or during the transport, this systems allows for passenger in the increased rate predict and select the route or different way of transport. Important function of information systems is their use to present ac-
tual information directly to drivers, it allows more efficient use of the road network.

3.2 Systems for vehicle park management (AFMS)

Systems for vehicle park management use a lot of technologies for improvement of safety, efficacy and also control of operation within the frame of vehicle park, also for vehicles in the case of emergency situations and also for provision of services. The module of vehicle park management allows for branched centre permanent access to current data about the vehicle and by this way it provides clarity and predictability of planning in transport processes. Control of vehicle park provides these data:

- messaging,
- continuous monitoring of vehicle,
- evidence of operational data,
- report of route,
- history of reports,
- cooperation for road vehicles providing.

Additional systems for vehicle park management are:

- routes planner (e.g. Logiweb tour),
- monitoring of shipments (e.g. Logiweb track),
- automatic identification (AVI) and classification (AVC),
- weighting during the motion (WIM),
- automatic monitoring of vehicles (AVM),
- automatic determination of vehicle position (AVL).

Route planner (logiweb tour)

The route planner for road vehicles allows changing of the determined and planned route by the need (change, cancelled, added stops for loading or unloading of shipment). During the route, the main dispatching is informed about the current state and by this fact, there are detected anomalies from the required terms. The final stops on the routes are formed automatically depending on the order data.

Monitoring of shipments (logiweb track)

“Logiweb track” is monitoring of shipments [17]. A shipment is monitored from its receipt until its delivery. Driver of the vehicle by the help of device computer technique (telematics unit in the vehicle) documents every step of shipment (Figure 1). The road driver uses to track the shipment telematics unit in the vehicle during the whole route so the joint holder of transport can obtain information when and to what extent the goods is being taken over by transport.

Figure 1: Monitoring - telematics unit in the vehicle - releasing factor driver of the vehicle [17].

The module “Logiweb track” with connection of telematics data of road vehicles with existing contract offers information which customer needs to establish to own internal enterprise processes. Early notification of transport delay can for example effects the plan of loading and unloading and occupancy loading ramps at consignor.

Detection of vehicles

Detectors used in the road transport are technical devices monitoring the current traffic situation in the specific place. By them it is possible to provide dynamic traffic management, strategic traffic management and obtain the necessary traffic information.

These systems include three functional elements:

- detector compound of sensor produced basic impulses and own detector which modifies these impulses for the next registration,
- registering device,
- decoding device.

It is possible to separate own detectors by different criteria, for example:

- principle of the detector sensor activity,
- registered value;
- number of characteristics which the detector is able to monitor and separate simultaneously,
Detection of pressure in axles

1. Contact threshold – it is allocated in the road, more modern on the road. It measures the passage of axles of all vehicles. By passage through the contact thresholds it occurs to depression of the top board and connection of contacts. The disadvantages are affected by the accuracy of weather and oscillation of the sprung mass of the vehicle after passing, this causes damages of the road cover.

2. Pneumatic or hydraulic hoses – they are allocated on the surface of the road and they measure the passage of vehicles. By transit of vehicle is created a pressure collision on the hose and it is converted into electrical impulses in the electro-pneumatic switches. This consists of a membrane and spring contact and by dent in the membrane the electric circuit is closed. Due to the quick installation, they are used for short-term survey of intensity. The disadvantage is the possibility of theft, damage by road maintenance, placement on the pavement and the curb. In winter, it is unusable.

3. Coaxial cable – it is a newer type of detector. It is stretched across the road and transit of vehicles is recorded by piezoelectric effect. They are able to distinguish vehicles according to axle load by weight categories. The advantage is an easy assembly.

Weighting during the movement

1. Systems with bending board – These systems were developed and patented in Germany in the company BAST with applied steel board – sheet metal with high resistance, strong 16 mm, it is possible to use for dynamic weighting by high speed. The measure of the board is $1220 \times 500$ mm. Two or three of them are used to cross the traffic lane with covering of both of the track wheels (Figure 2, [17]).

2. Deep weight - Automatic highway weight created by the University of Saskatchewan is the system with deep depression with two rectangular weighing platforms allocated on the common concrete base. The platforms are allocated in each track run. The load of the vehicle, which is reflected on the platform, is caused by vertical movement in the centrally located piston full of oil which serves as a load scanner. This system, based on inductive loops and monitoring systems at the edge of routes, allows to measure the range of parameters on the vehicle.

Figure 2: Weighting of vehicles during the movement [17].

Automatic monitoring of vehicles

Systems for automatic vehicles monitoring (AVM) are a combination of coherent systems with various devices in the vehicle. Devices installed in the vehicle are ranging from simple tachographs through taximeters or management systems full based on the board-computer.

Electronic tachographs. The tachograph is intended to identify the time of the driver, vehicle speed, distance and vehicle operation. Information is recorded on a special diagram versus time scale by several pins. Each tip creates a clear, enough accurate track and its location on the disk enables a clear analysis for determination of the movement and speed of the vehicle.

Taximeters. Taximeters, which were developed for calculating of mile post in taxis were developed for measurement and recording of characteristics of vehicles and driver. The latest are able to monitor distance, time, speed, fuel consumption, engine speed and other operational parameters. These information are recorded to the register and cab be developed by the computer on the monitor.

On-board computers. They are used to collect of internal data about the vehicle that record to the memory for subsequent analysis and review. Basic systems of on-board computers are simple, registering basic information about the vehicle such as: mileage and speed data, temperature of oil, engine, water, etc. The obtained data are stored in a removable module (cartridge, card, etc.) or to the devices inside the computer. Transmission device is inserted into the home base connecting by communications cable. The route of vehicle consists of the activities of the driver since he enters to the vehicle until the completion of driving. Compared tachographs they have a lot of advantages. They allow to provide more accurate management and diagnostic information about the vehicle and allow monitoring of the driver. Their activity does not require any input from the user and thus reduces paperwork for driver. On the other hand, they do not allow to transmit the data to the headquarters, until the end of drive because the data transfer requires physical connection to another computer. Between the dispatcher and the driver the communication in real time is not possible and there are
no data about the position of the vehicle until it is on the way. Improved on-board computers provide, for example an electronic recorder of driving. It can have the form of an integral electronic book and it can contain various information, such as vehicle speed, excessive speed, unwanted interferences with the vehicle, etc.

Use of electronically controlled systems allows further improvement in the field of economy and especially in the field of active and passive safety of drivers, and this fact can decrease number of accidents, or reduce the consequences. The most widely known currently used electronic systems are:

- anti-locking systems, control of retarders,
- control of fuel systems including the mode of braking by engine,
- regulation of suspension and damping of suspension,
- shift of speed stage,
- managing.

Fleet Controlling. Fleet Controlling is one of the telematics systems used in logistics enterprise. On the base of online locational and technical information from the vehicle and with combination with information from other information systems (Enterprise Resource Planning - ERP, Customer Relationship Management - CRM, actual transport data) it is possible to evaluate the situation and transmit alarm signals with predefined situations (unplanned stop, diversion from the route, inability to meet the transport plan, inefficient driver behaviour – for example prohibited break). This solution allows access to other enterprise information systems and advanced work with tasks. Optimization mechanisms generate the best routes and itineraries. System “Fleet Controlling” also allows message for drivers, their time fund, agenda of vehicles and techniques for accounting and legislative needs. Senior managers have the possibility of immediate control and communication with operators or drivers also information in the form of reports for ex-post analysis and data interconnection, including import of data to the other systems (i.e. accounting, Customer Relationship Management - CRM). Control function is realized in relation with signal plans of signal lights, possibilities of control by installed telematics application, above all command and prohibition variables of traffic signs and system of guidance. The base of rules and scenarios perform processes of control on the base of evaluation of transport data and transport information.

4 Discussion

The future of transport is inextricably linked to intelligent transport systems (ITS). These intelligent systems are already helping solve problems of transport systems. Intelligent transport systems represent a interconnection of new information and telecommunications technologies and management systems for vehicles and infrastructure networks. Generally speaking, it is a system for managing and directing traffic, solutions its safety and flow of traffic. The issue of ITS has a relatively wide range in both the spectrum of services offered, as well as the possibilities of its usage, ITS provides a comprehensive view of the transport systems. The aim of the use of ITS is more efficient functioning of transport systems, improve safety, increase productivity and economic efficiency of transport and contribute to improving the environment.

5 Conclusion

The reason for implementation of intelligent transport system is optimization of enterprise costs. Financial funds for purchase and implementation of new system of management is needed to plan in the long-term perspective. Savings is not possible to expect in a matter of weeks, but months or years. Despite of all problems, it is possible to present economic benefits. It is possible to determine the expected difference in work organization, communication, socio-economic conditions in the enterprise, possibilities of coaching, reporting, but the most important goal is to obtain control over expenditure, vehicles and staff. Accurate statistics of the number of carriers in the Czech Republic does not exist, it is estimated at about 30 000, it is 600 000 registered trucks. Their perspective is considering the current market situation very complicated. Extremely long maturity of invoices, rising prices of toll, rising fuel prices and low prices of services, pushing their margin to zero. International carriers are affected by strong crown which surcharges roads to abroad. Boom of logistics and grow of turnover in the field of transport, developed competitive environment across Europe, strong pressure from customers on prices, constantly implementation of restrictive measures in the EU, forces carriers to put the accent on the efficiency and searching of reserves.
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