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Towards Improved Protection of Vulnerable Road Users

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ABSTRACT: The paper aims at reducing injury risk and an overall increase in pedestrian passive safety by proposing pedestrian friendly vehicle design. Statistical data are used to identify the most vulnerable population group also regarding the economic losses caused by deaths or medical treatment. An age dependent anthropometric approach enables the development of specific virtual pedestrian biomechanical human body models. The developed virtual pedestrian models are explored to analyse the influence of vehicles in pedestrian impact on injury risk caused by a vehicle industrial demonstrator using numerical simulation. The analysed injury criteria serve for a comparison of vehicle frontal part design variants.

KEY WORDS: Vulnerable road user, anthropology, safety, simulation, optimization.

1 INTRODUCTION

Traffic accidents are within a group of external consequences causing the third highest number of deaths in the Czech Republic, just after deaths caused by falls and suicides (Czech Statistical Office, 2007). The numbers of deaths or fatally injured citizens prove that traffic accidents and their consequences are still a serious problem to be solved. The statistics show that the number of accidents has been decreasing slowly in the past years (Skácal, 2007 and the Ministry of Transport of the Czech Republic, 2010). However, the decrease needs to be sped up regarding also the socioeconomic aspects of the problem (Daňková, 2007).

Traffic accidents cause either physical losses, such as death, fatal injuries and physical damage, or also psychological traumas. Traffic accidents' consequences are carried, not only by the government, but also by the state budget, due to production losses, widow and orphan allowances and disability pensions. Traffic accidents account for more than 1,300 deaths, 6,000 fatally injured and the society losses costing over 49 billion CZK in the Czech Republic yearly (Daňková, 2007). Such a negative trend necessitates urgent actions to be taken in order to change the situation.

2 MOTIVATION

A lot of effort is devoted to both passive and active safety systems development, where virtual human body models start to play significant role, since they become powerful tool for supporting the development of human-friendly and safe vehicles through a numerical method using computer simulation.

The body stature, gender and age play a considerable role within the traffic accident. This means that several groups of people suffer higher injury risk due to traffic accidents. These groups are mainly children and elderly people.

Consequently, it is necessary to develop and validate correct biofidelic models (Haug, 2004). Based on the injury description implemented in the virtual human model, they might predict the human body response just by computational time. Hence, a lot of structural designs, technical solutions, and impact scenarios might be analysed before getting into experimental development and further production. The virtual human models contribute not only to the safety systems development, but the virtual prototyping as a complex development approach also reduces the production process costs and contributes to the protection of the living environment.

3 METHOD

The problem investigated in the paper and the presented results are based on the results of the research project CG911-044-150 "Reduction of accidents consequences of vulnerable road users in Czech population" supported by the Ministry of Transport of the Czech Republic within the years 2008 – 2010. The aim of the project was to increase the passive safety of vulnerable road users and reduce injury risk by the new design and construction of passive safety devices using numerical simulation. Existing software enabling the anthropometrical scaling of the basic male, female, and child models depending on an age from 6 to 55 years was extended by child anthropometrical data under 6 years, elderly anthropometrical data over 55 years, and further biomechanical data over the population. The developed virtual biomechanical models of vulnerable road users were used to analyse the influence of vehicles in pedestrian impacts in injury risk using industrial demonstrators. Based on injury mechanisms analysis, new structural designs of the vehicle front end which reduced the injury risk of vulnerable road users were proposed and analysed.

The paper focuses on the territory of the Czech Republic and the main task is to reduce accidents consequences of vulnerable road users in the Czech population. The paper describes the identification of the most vulnerable group within the vulnerable road users regarding gender, age, and typical accident. The research also takes into account the socioeconomic aspects of the traffic accident including a vulnerable road user. The algorithm scaling a virtual human body model to the identified specimen is then presented and the identified accident is provided by numerical simulation. A simple process to develop structural changes to the impacting vehicle is applied, and the numerical simulation using the optimized vehicle is reproduced to propose technical improvements leading to a decrease in the injury criteria values and so reducing the accidents consequences of the vulnerable road user.

3.1 Identification

The accident analysis and the related socioeconomic costs identification come from the yearly reports issued by the police (Tesařík and Sobotka, 2008), BESIP (2008), data and scientific papers by the Transport Research Centre (Skácal, 2007), the Ministry of Transport of the Czech Republic (2010), and mainly statistical data of the Czech Statistical Office (2007). The aim of the identification was to:

- Identify the most injured group of vulnerable road users;
- Summarize the related socioeconomic costs.

Based on the above-mentioned project investigation (Hynčík et al., 2011), the most injured road users were identified in the following groups:

- Citizens between 20 and 24 years old, between 50 and 54 years old and older than 75 years;
- Pedestrians as belonging to most injured road users;
- Males as having a higher death percentage than females.

The studies summarizing the socioeconomic costs directly related to the age of the injured citizen are currently missing. Hence the following statements flow from the generally available data. From the socioeconomic point of view, the highest losses are related to the citizen's death, fatal injuries, or production losses. The production losses take into account the GDP (gross domestic product) coming from the number of citizens of productive age (males from 15 till 62 years old, females from 15 till 60 years old).

The available data summarized by Hynčík et al. (2011) prove that the socioeconomic costs related to the death exceed twice the costs related to the fatal injuries and greatly exceed the costs related to minor injuries or physical damage.

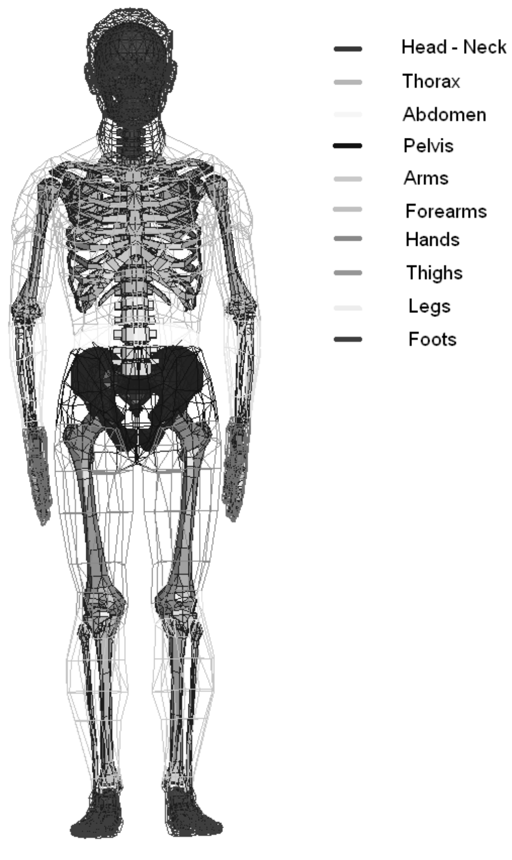

Figure 1: Human articulated rigid body model.

The major part of the socioeconomic costs is shaped by indirect costs which include the production losses and the related social expenses. The indirect costs are just as low as the severity of the traffic accident. The direct and indirect costs are not so different except in the case of death. The indirect costs are even higher than the direct costs with minor injuries.

From the socioeconomic point of view, the most unfavourable traffic accidents are those including the death of a citizen at a productive age. Hence the main task is to eliminate fatal traffic accidents where the productive age citizens participate. Taking into account the existing safety systems development for the average population, and based on the above socioeconomic costs identification, the following group of vulnerable road users is taken for further investigation:

- Male pedestrian aged between 50 and 54 years (with an average of 52 years old);
- Municipal area passenger car impact at a speed of 50 km/h.

3 percentiles (5%-tile, 50%-tile and 95%-tile) based models aged 52 years are developed by scaling the original model and the passenger car's impact is numerically simulated. Several structural changes to the car's front end are proposed and the pedestrian injuries are analysed according to this optimization.

3.2 Modelling

The current experimental development of safety systems use the standardized dummies that are fully tuned for the specific impact description. However, they are not completely biofidelic and furthermore, they represent only a limited set from the population.

The basic model used for investigation is the 50%-tile male model called Robby, developed by Hynčík (2001). The model consists of rigid bodies separated into segments connected by biomechanical joints (Robbins, 1983). The model also contains all main skeletal muscles implemented (see Figure 1) and injury criteria (Schmitt et al. 2004 and Cichos et al., 2006).

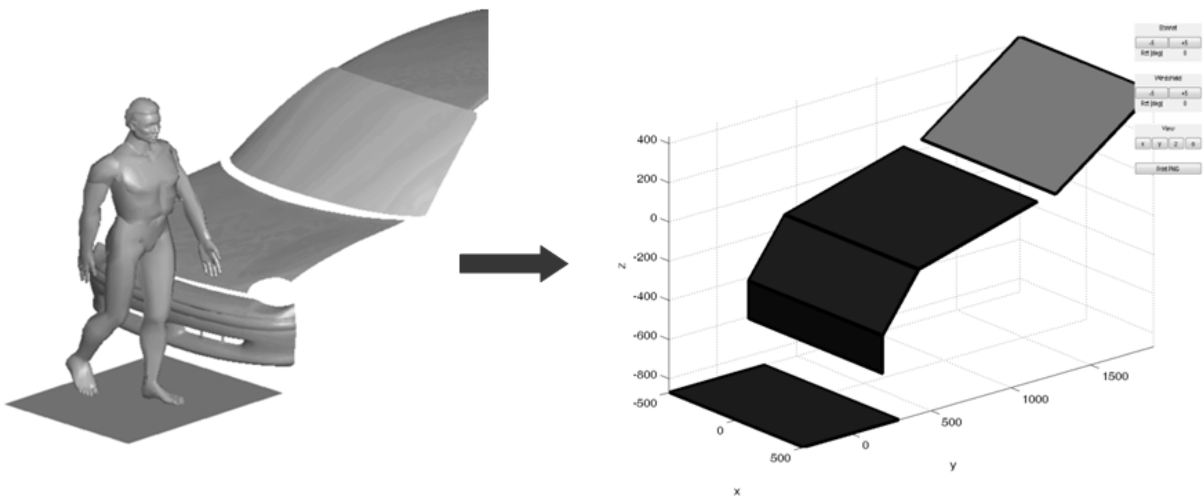

Figure 2: Pedestrian impact position: car demonstrator (left) and simplified model (right).

However, everyone is different from an anthropometry point of view and the separation of the overall human body population into categories such as 5%-tile, 50%-tile and 95%-tile (not age dependent) is not enough from an application point of view. Moreover, the development of a particular human body model for any population specimen is not possible.

Hence, based on a wide literature review, a scaling algorithm has been previously developed (Hynčík et al., 2007). The algorithm scales a reference model separated into segments connected by joints, updating its major anthropological dimensions and dynamical properties. The update of the algorithm is done by adding additional anthropometrical data (Bláha et al., 1985) and scaling joint flexibility based on age (Araújo, 2008).

Based on the scaling algorithm and the above identified accident scenario, a 52 year old pedestrian model is developed for further investigation. Since the anthropometric data implemented in the scaling algorithm contains various population percentages, 3 models (5%-tile, 50%-tile and 95%-tile ones) are developed for numerical analysis and comparison. The models are further referred to as *p05a52*, *p50a52* and *p95a52*.

3.3 Impact simulation

As identified in section 3.1, the most vulnerable road user is a male pedestrian aged between 50 and 54 years in a municipal area in an impact with a passenger car at the speed of 50 km/h. In order to have a reference scenario for comparison, a similar accident described by Kerrigan (2005) is taken into account as a reference one.

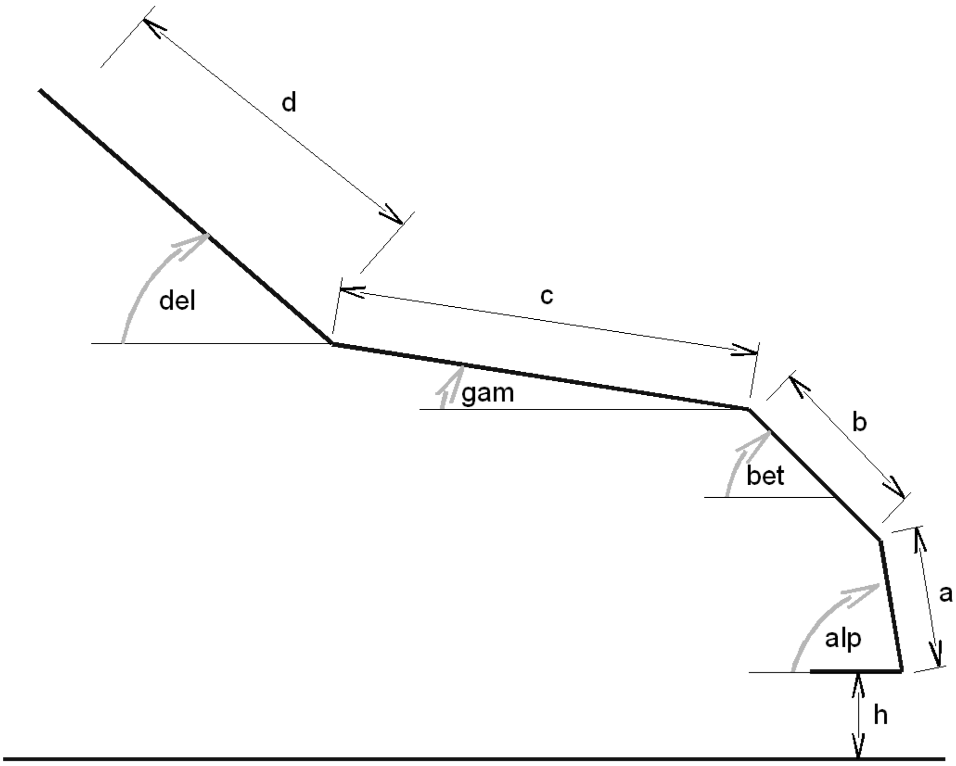

Figure 3: Parametric vehicle front end design.

The standard available car model is taken as a demonstrator (see Figure 2 left). In order to have a simple model description for further optimization, the model is simplified (see Figure 2 right) and parameterized, as shown in Figure 3.

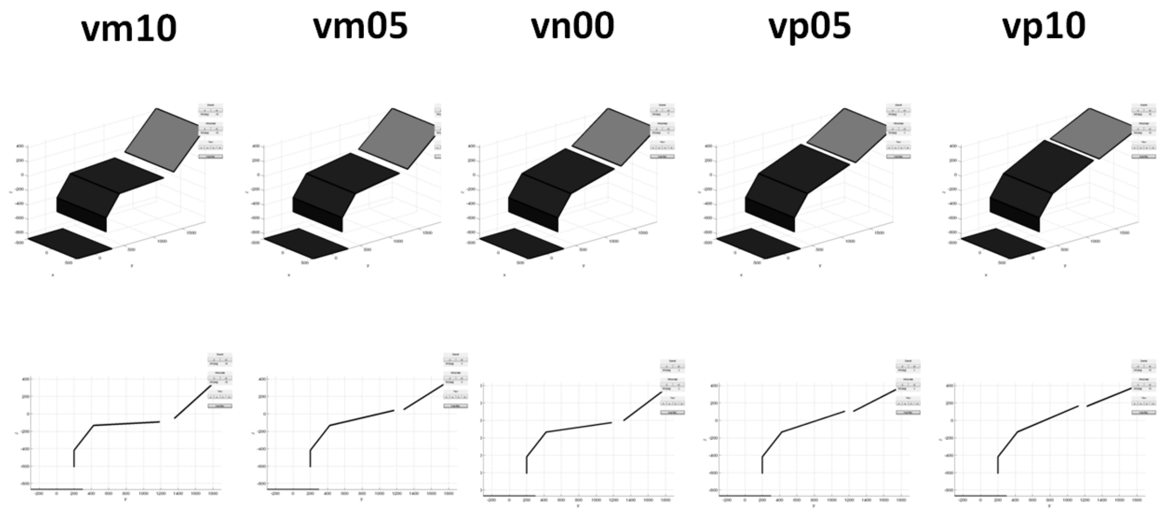

Figure 4: Optimization of vehicle front end design.

The contact between the car and the pedestrian is the crucial thing to be implemented in such simulations. Correct contact modelling in rigid body based approach to biomechanics is crucial due to the high deformation of biological materials. The energy absorption must be implemented in the internal contact variables due to the rigidity of the contacting bodies. Kerrigan (2005) describes the contact response between a human body and a particular car part (bumper, bonnet, and windshield) that are necessary input data after positioning the human model to the impact position (see Figure 2).

Table 1: Car front end optimization.

Variant	*vm10*	*vm05*	*vn00*	*vp05*	*vp10*
Bonnet angle	-10°	-5°	Original model	+5°	+10°
Windshield angle	-10°	-5°		+5°	+10°

The basic model has been validated firstly for the standard impact conditions (Kerrigan, 2005) and then several variants of the car front end structural design (see Figure 4) have been developed for analysis of its influence on injuries caused by pedestrian impact. The original car model is referred as *vn00*. Additional variants *vm10*, *vm05*, *vp05* and *vp10* are developed (see Figure 4) so that both the bonnet and the windshield are rotated by 5 or 10 degrees in both negative and positive senses relative to their original positions. The analysis is in line with Regulation EC No. 78/2009 on vehicles parameters evaluation.

4 RESULTS

Numerical simulations of the pedestrian impact with all the developed car front end variants and 52 year old 5%-tile, 50%-tile and 95%-tile human models are developed. The results of the simulations show the injury probability dependence on the car front end structural design.

Table 2: Human percentile and front end design dependent head injury criterion.

Variant	*HIC*				
	vm10	*vm05*	*vn00*	*vp05*	*vp10*
p05a52	8 562	8 739	3 912	2 311	1 684
p50a52	4 365	2 620	1 901	1 517	1 227
p95a52	2 449	1 847	1 389	1 173	1 018

Table 3: Human percentile and front end design dependent 3ms criterion.

Variant	*3ms*				
	vm10	*vm05*	*vn00*	*vp05*	*vp10*
p05a52	69	69	65	65	65
p50a52	57	57	62	54	50
p95a52	43	40	46	38	39

Concerning the pedestrian impact, the head injury criterion (*HIC*) and the thorax injury criterion (*3ms*) criterion are analysed for 3 pedestrian percentiles and 5 car front end structural design including the original one. Table 2 shows the head injury criterion dependence on the car front end structural design for all 3 analysed pedestrian percentiles, whilst

Table 3Table 3 shows the thorax injury criterion dependence on the car front end structural design for all 3 analysed pedestrian percentiles. Both the head injury criterion and the thorax injury criterion are also illustrated on the bar graphs in Figure 5 and Figure 6.

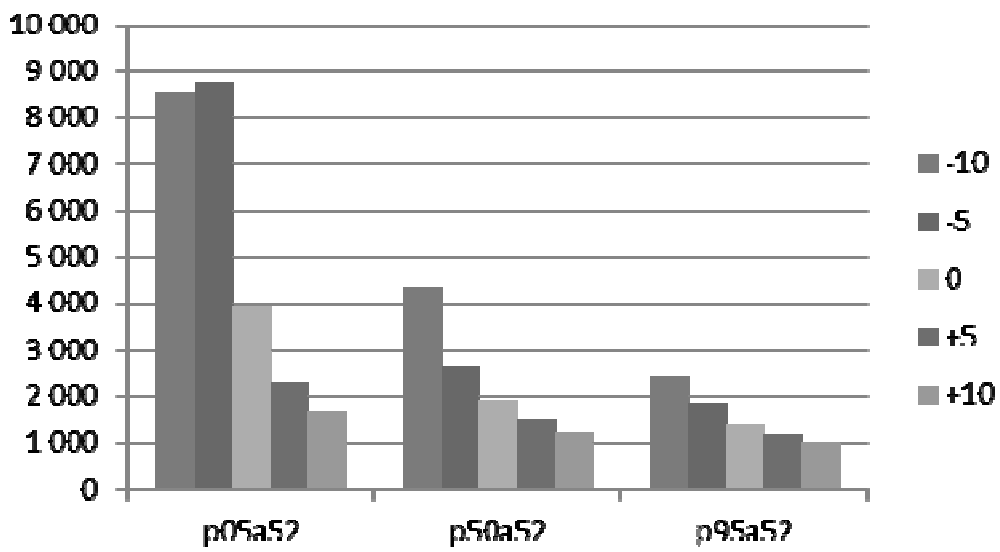

Figure 5: Human percentile and front end design dependent *HIC*.

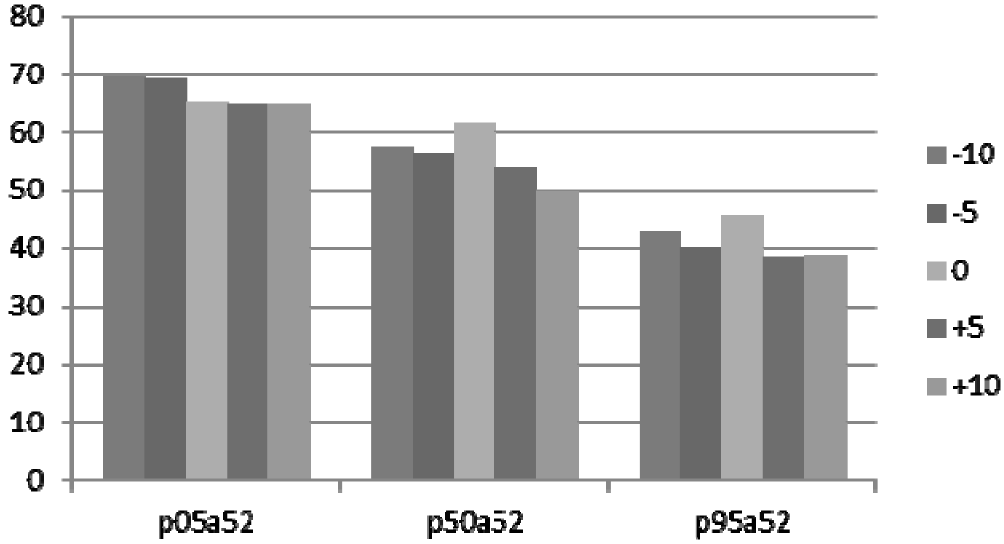

Figure 6: Human percentile and front end design dependent *3ms*.

5 DISCUSSION

The bar graphs in Figure 5 and
Figure 6 show a significant influence of the car front end structural design on pedestrian injuries. Furthermore, the results prove that different people according to their body status suffer very different injuries, measured by the injury criteria. Based on the graphs, it can be stated with minor deviations, that the lower angle between the bonnet and the windshield causes lower injuries on the head and the thorax. Whilst the thorax injury criterion is under the limit for all cases (Schmitt, 2004), the head injury criterion considerably decreases by flattening the angle between the bonnet and the windshield.

6 CONCLUSION

The paper contributes to increasing the passive safety of vulnerable road users and to reducing injury risk by analysing the car front end structure using numerical simulation. Virtual biomechanical models of vulnerable road users developed by scaling were used to analyse the influence of a vehicle's structural design on injury risk using a demonstrators. Based on the injury mechanisms analysis, the car front end shape design was analysed for vulnerable road users.

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The Anticipated Impacts of Road Pricing on the Quality of Life in Prague City Centre

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ABSTRACT: Growing traffic in urban areas is linked with the increasing problems of congestion and environmental degradation. In response to this there are a range of potential instruments for dealing with traffic-related issues in urban areas, one such option being road pricing. Congestion-charging schemes have been successfully implemented in many cities; however the Czech Republic does not have any experience in this field. The future impacts of ETC (Electronic Toll Collection) if implemented in Prague were obtained from transport models. The decision on the efficiency of this instrument with respect to the expected Quality of Life (QoL) has been acquired as a result of the Delphi method process.

KEY WORDS: Congestion, congestion pricing, QoL, Delphi method.

1 INTRODUCTION

The frequency of the appearance of traffic congestions, and their intensity and duration in urban areas are usually tightly connected with urban economic development, employment, housing and cultural policies that make people want to live and work relatively close to each other, and attract firms to benefit from the gains in productivity thus derived (OECD/ECMT, 2007). Congestions are likely to continue to increase in locations where the population and city economies are growing, transport infrastructure development does not follow the road networks capacities required growth, and population has not been motivated enough to apply public transport alternatives instead of individual vehicle transport. Congestions cause traffic jams, slower speeds, and increased travel times which impose costs on the economy and generate multiple effects on urban regions and their inhabitants. It also has a range of indirect impacts, including environmental (air pollution, noise) and resource ones, impact on the QoL, measured, for example, by stress and safety, as well as on non-vehicular road space users. Especially due to these negative impacts, ways to reduce congestion have been sought. There are two approaches on how to reach this, either based on increasing the roads system's capacity (supply), or by reducing traffic (demand). The traditional road administration's approach to handling current and expected future traffic demands relies on adding more capacity over the whole of a route, creating new routes, and traffic management improvements. Additionally, various instruments have been implemented to regulate the demand for transport and thereby regulate traffic itself: direct and indirect taxes on vehicles and on petrol, higher quality of public transport, traffic regulations, and parking restrictions. Development within information and communication technology has also improved the possibility of using various forms of electronic fee collection.

Road pricing as a policy to alleviate congestion, environmental, and other problems related to urban and interurban road transportation, however, has not been implemented on a broad scale. It is widely considered to be a radical and controversial policy, as the public and politicians do not seem to be convinced of the benefits, either to society or to themselves. On the other hand, there are also long-lasting disputes among academics, especially concerning the application of the concept of marginal road pricing (Jensen-Butler, 2008).

2 WHY ROAD PRICING

The idea of road usage fee/toll collection as an instrument to tackle road congestion is based on an economic theory from the early 1960s in which authors developed the standard road congestion analysis to demonstrate that the market equilibrium derived from non priced road users in excessive congestion. The key was to set the price of driving equal to the social marginal costs that would reduce traffic to its optimal level. When talking about the purposes of road pricing it usually refers to:

- Collection of revenues;
- Reduction of traffic and nuisance (negative externalities, such as congestion, environmental damage, noise, etc.);
- Promoting efficiency.

The longest standing urban road pricing scheme was pioneered in Singapore as an area licensing scheme in 1975; in 1999 it was replaced with an electronic road pricing scheme (ETC). The purpose of the system is to reduce traffic in order to increase accessibility in selected area. The basis for the charge is to achieve a target-speed that gives improved accessibility. If the average speed drops, the fees increase, and vice versa. The fees are revised every third month.

In the case of Norwegian cities (Bergen, Oslo, Trondheim, Kristiansand, and Stavanger) where a toll was introduced during the years 1986 – 2001, the original target was to collect revenue to carry out specific investments that would take too long to be completed.

Both London and Rome suffered from severe congestion and environmental problems. In Rome the pricing system, which comprises of charges for permits to access the central area, is still quite limited. Clearly, the most important example in Europe is represented by ETC installed in London, where the urban road pricing was introduced on February 17, 2003 as a brainchild of the first elected mayor of London, Ken Livingstone. He had three major objectives in introducing the charge: raising revenue, promoting public transport, and, of course, reducing congestion. Initial impressions were that the charging system was very successful, achieving a 20 % reduction in traffic with none of the major problems that were not predicted. However, over time London has gone through various phases with a change of price and an extension of the size of the charged zone.

- 2003, Feb. 17: charge £5.00, charged area, 22 km^2 (London central business district, major part of Westminster);
- 2005, July 5: charge £8.00;
- 2007, Feb. 17, expansion of the charging zone (Western extension);
- 2011, Jan. 4, charge £10.00, Western extension switched off.

Finally the congestion returned to the initial level. The reasons have to be evaluated; however, as a result of this outcome the Western extension was excluded from the charging area, and the charge was increased to £10.00.

3 ETC IN THE CZECH REPUBLIC

Evidently, there are globally recognized strong barriers to urban ETC implementation that are the main reasons why this instrument has been applied quite rarely. Ninskanen et al. (2003) made the following classification:

- Technological and practical barriers;
- Legal and institutional barriers;
- Acceptability of related barriers (public, business, and political acceptability).

The Czech Republic belongs to the group of countries where urban ETC has not so far been implemented. Even so, there are noticeable signals that, in the case of the capital city, Prague, some introductory processes, namely in the area of surveys and studies based on transport modeling, have already been carried out (i.e., studies provided to the Prague Municipality by Evions, a.s. 2008, published, however, in Czech only).

Referring to the barriers mentioned above, in the case of Prague, all of the barriers shall be taken into account when discussing the possible implementation of urban ETC. Each city where urban ETC is accepted for upcoming implementation should act independently in relation to the stated future objectives. In the case of Prague, the major targets have been stated by the Prague municipality as the following:

- Improving the environment and the protection of cultural heritage;
- Improving the transport situation in the city centre;
- Building the instrument for managing traffic flows in the city centre;
- Multi-functional systems (security, transport modeling).

With regard to the accessibility of relevant data and transport modeling outcomes the aim of the evaluation is the assessment of the impact of congestion charging on the QoL in the city centre (within the zone of charging). QoL is a multidimensional construct that may be defined as the extent to which important values and needs are fulfilled. QoL refers to well-being, conceptualize either in term and objective living conditions, or as a person's own assessment of his or her well-being in life, or both. Therefore, the group of parameters has been chosen, and their combination has been appraised as representative enough and the QoL represents in this special case. These are as follows:

- Economic development of the charging zone (the impact of congestion pricing on economic activities and development);
- Environmental living parameters (the impact of the instrument on emissions and noise burden);
- Quality and accessibility of alternative transport (above all urban public transport).

The selection of the above-mentioned parameters relates to both the accessibility of the relevant data and modeling instruments, and the experience of the cities which have already experienced the implementation of congestion pricing.

The outcome of the transportation models indicates that a result of congestion charging implementation is a decline in the amount of traffic. This fall varies depending on the chosen charging zone and congestion charging level.

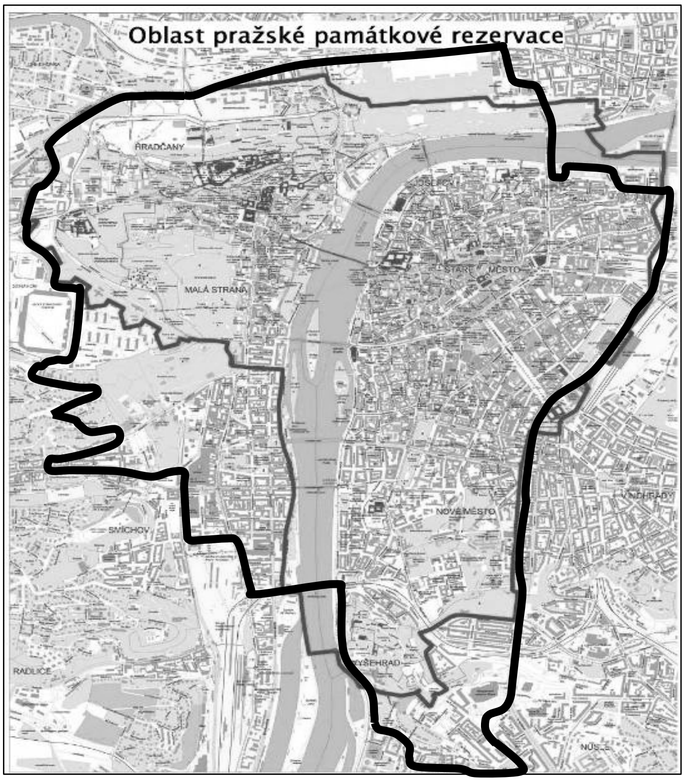

Figure 1: Largest option of congestion charging zone (boundary of the zone is marked in green)

In the target year 2020, with the planned Prague road network, comprising of the urban ring and the Prague ring road, seven radial roads, and two conjunctions, a reduction in the number of vehicles is expected of between 12 and 25 % (up to 35 – 74 thousands vehicles daily), which corresponds to experience gained from abroad: in the case of London a year after the congestion charge introduction the drop was of approx. 18 %, in case of Stockholm about 21 %. With each of the tested versions the fact that part of the transport from the city centre will be transferred to the bypass roads is be counted with.

Generally, the urban ETC implementation will result in a redistribution of traffic flow on not only the road net within, but also outside of, the suggested charging zone. It can be anticipated that the decline in the number of vehicles in the city centre (due to the congestion charging) will proportionally cause an increase of the transport burden on the alternative bypass roads as a result of the effort of some drivers to drive close to the charging zone boundary; others will decide for alternative forms of transport, or even decide not to drive into the charging zone. Urban ETC therefore represents an instrument that changes the behavior of the individual vehicle users.

The reduction in number of vehicles in the charging zone shall logically imply less pollution caused by individual traffic. This presumption was verified in five reference subareas with a higher concentration of pollutants and noise. The results confirmed the expectations of pollutant concentration and noise level changes. Concerning the case of emissions within the charging zone due to congestion charging a decrease in the emission concentration levels of pollutants was identified. Outside of this zone, especially with respect to the increase in the transport amount on the alternative bypass roads, the emission concentrations increased. The quality of air in the charging zone was improved, due to the reduced number of vehicles and the density of congestion; however, every situation is specific and depends on the actual atmospheric conditions (the appearance of frequent inversions), wind directions, together with the local landscape morphology.

In the case of noise load examination, again only in the reference points, the important influence of the congestion charging implementation has failed to be proved. For this reason noise impact can be understood as a less important parameter.

Epidemiological and toxicological studies indicate that transport-related air pollution can affect a number of health outcomes; however, commonly accepted selective quantification has not been yet accepted. Transport traffic pollutants contribute to the increased risk of death, particularly via cardiopulmonary syndromes, and pollutants increases the risk of non-allergic respiratory symptoms. Laboratory studies point out the fact that transport-related air pollution increases the risk of developing an allergy and can exacerbate symptoms – in particular, in susceptible subgroups (Laden et al., 2006). However, according to the WHO the relation between adverse effects on health and exposure to transport-related air pollution still needs to be elaborated and more research is needed, e.g., to clarify which constituents of traffic emissions are responsible for the observed adverse effects (WHO Regional office for Europe, 2005). Based on the conclusions and recommendations of the WHO it can be agreed that the only possible solution in order to avoid further traffic-induced harm to human health is to reduce the total growth in traffic, especially in urban areas (WHO Regional office for Europe, 2000). In this sense, congestion charging certainly represents an important instrument.

The public transport system of Prague is evaluated as one of the most advanced systems in Europe. It is used by almost four millions passengers daily. Some limited and selectively spread capacities are still identified in the existing public transport system available for passengers who decided to change from their vehicle transport to public transport. These capacities can be used without the need for principal changes in the current regime. Any additional financial resources stemming from ETC implementation would mean, in the case of their investment into public transport, an important improvement in its service density coverage and service quality.

Implementation of ETC in Prague as a transport system control tool represents an extremely sensitive topic. It is not a only technical, but also a broad sociological, and, therefore, surely also a political issue. Therefore, urban ETC technical solutions, not only in Prague, but also in the other cities of the CR, as well as in other places in Europe, North America, and Asia, are far ahead of political decisions on their implementation.

4 DELPHI METHOD

In order to assess the efficiency of selected restrictive measures the Delphi method was accepted for evaluation, as it enables representative multilateral appraisal of a problem and adds independent experts' statements to the issue. Ten independent experts participated in the survey – these were representatives of the state administration (Ministry of Transport, State Fund for Transport Infrastructure), the City of Prague (Technical Road Administration of Prague), the private sector (IBM Czech Republic Ltd., MOTT MACDONALD Praha, Ltd., INTENS Corporation Ltd., Czech Railways, and the University (CTU Prague, Faculty of Transportation Sciences). Selected experts represented the following branches: the strategy of transport development in the CR, ITS conception and implementation in the CR, financing of transport infrastructure development in the CR, consultancy (economic – technical), in the transport systems branch, economics and the management of transport systems, and transport process modeling. Each of the experts worked completely independently with the aim of avoiding the psychological barrier stemming from the immediate reaction resulting from direct contact. The document, comprising all the criteria with comments, was drawn up in order to reflect all positives and negatives from possible road pricing implementation. The experts focused on overall assessment, including not only the impacts of the toll in the charging zone, but also the impacts in the area outside of the charging zone, where negative effects can be identified as a result of the traffic increase on the bypass road systems. The questionnaire comprised of the following hypothesis:

- The ETC presents a useful instrument for traffic flow regulation in the charging area with the impact of a decrease in congestion potential;
- The ETC has a neutral impact on the economic development of the charging area;
- It is a flexible instrument – e.g., with the height of the charge the efficiency of the instrument can be continuously increased;
- Transport models (with regard to foreign experience) enables the predication of the impacts of ETC implementation in the charging area;
- The ETC is a suitable source of investments into non-motorized transportation in a city (especially in public transport);
- The ETC is a suitable instrument for developing a given area, if the transport regulation is successful (a possible instrument of reurbanisation);
- If the transport regulation is successful the ETC may have a positive impact on monument protection;
- The efficiency of the ETC may be lower in the case of insufficient construction of transport infrastructure;
- There is lack of current data for transport models;
- The public acceptance of this instrument can be low, with possible political impact, etc.

The applied methodology was based on a two round assessment. In the first round each of the participants provides the weighting coefficient for each criterion, a value of 0-10 with an explanation for his/ her evaluation. The results are processed by the arithmetic average. In order to eliminate the influence of extreme values the responses with the highest and lowest values were omitted. In the second round of assessment, each participant was asked to reconsider a possible correction on the basis of information provided about the outcome of the first round. The evaluation results in the second round are processed by the same method as was applied in the first round.

According to the numerical results (56.1 positive points and 52.6 negative points) the outcome from the first round can be understood as a slightly positive tendency of experts towards the road pricing implementation, as it is considered as a rather effective tool for traffic regulation in the city center. After the second round (55.685 positive points and 54.372 negative points) it can be stated that the group of experts practically reached a consensus in the number of positive and negative points. The outcome of the group of experts assessment with a wide range of knowledge and skills can be evaluated as neutral towards the effectiveness of road pricing, i.e., political representatives have to enter the decision making process on the application of this relatively controversial regulation instrument. In comparison to a relatively broad consensus of experts, politicians can change the importance of certain selected parameter(s).

To sum up, the final decision on the road pricing implementation is a question of political choice. In the case of the CR there is sufficient legislation permitting the introduction of such a restrictive instrument (this fact was mentioned in the questionnaire). The first necessary step is therefore the adoption of relevant legislation on a national level. The second step will be the decision of the Prague City Council. According to public choice theory political behavior and the decisions of individuals is driven by the same economic interests as the behavior of individuals on the market. The purpose is to maximize their own economic benefit (e.g., their personal wealth); in the case of politicians it is to be re-elected. Economic theory understands the motivation of politicians simply as their effort to maintain the privileged position of power, and, hence, the incentive to maintain favour with voters, respectively certain groups with major influence. This theoretical approach is consistent with the findings of the cities in which road pricing has already been introduced. Retrospectively there was stated that among the greatest barriers to the introduction of charges were political and public acceptance of this toll. In the preparatory phase of the implementation of this instrument it is therefore necessary to effectively communicate with the public. It is clear that, in general, people are against the introduction of any charge. The public, however, will be more tolerant of supporting such a regulation if they are properly informed about the objectives of the policy (i.e., solving a particular traffic problem). The proposed strategy is perceived as an effective solution to the problems, especially if the revenues are reapplied in the transport sector, and if the public have confidence in the protection of their privacy [11].

5 CONCLUSION

Road charging is increasingly being seen as a policy option capable of dealing with the problem of congestion in urban areas. The efficiency of this instrument is always dependent on the conditions of each city where the instrument is being introduced. In order to decide whether this measure might manage the traffic in Prague with regard to the quality of life on the basis of key findings from the traffic models the experts' survey was carried out.

Weights were determined by the Delphi method, involving a representative group of experts of different transport branches. The experts' findings were broadly neutral, therefore it can be stated that the final decision on the implementation of road pricing must be a matter of political choice. Nonetheless, the first necessary step of ETC is identified in the adoption of relevant legislation. The second step is represented by the decision of the Prague City council. Political and public acceptance of road charging belongs among the greatest barriers to its introduction. In the preparatory phase of the implementation of this instrument it is therefore necessary to effectively communicate with the public, as it is clear that in general people naturally oppose the introduction of additional charges. The public, however, may be willing to accept a pricing strategy if properly informed about the purpose and objectives of the decision, the effectiveness of instruments, if the revenue is reapplied in the transport sector, and if the protection of privacy is secured.

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Measuring the Electric Strength of Board Composite Materials and Insulators

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ABSTRACT: This article contains the results of electric strength measuring of board composite materials and electrical insulators. It describes and briefly specifies the measured materials, i.e., the composites based on Glass, Kevlar and Carbon fiber. The composite electrical insulators are Kartit, Glasstextite and Textite. The measurement description shows the measurement system diagram and parameters of the used testing high-voltage source. The evaluation suggests the possibility of using composite materials as electromobiles' construction components which require specific electrical properties.

KEY WORDS: Electric strength, composite, insulators.

1 INTRODUCTION

The electric strength is a parameter that characterizes electric-insulating materials. Its value dimensioned use of electric insulators in practice. New requirements for automobile construction parts emerged during the electromobile development in the research laboratories of the Institute of Progressive Technology for the Automotive Industry. This is particularly applied to the electromobile chassis. Function parts and battery boxes are consequently connected to the chassis. The battery boxes contain power contacts with monitoring and control elements (BMS). To achieve a higher consistency and lower automobile weight, it is important to simplify and merge certain construction elements. In our case, it is the unification of the chassis and battery boxes into one function unit.

Knowledge of the electric strength of the above-mentioned materials is therefore important for determining the safety of electric vehicle components. Understanding a material's electric characteristics is an important factor in the production of electric devices and electromobile development as well. The reason is to reach the maximum possible safety for electromobile operation.

2 THEORETICAL ANALYSIS OF THE EXPERIMENT

2.1 Definition of Electric Strength

Electric strength is the critical size of the electric field intensity in which materials lose their insulating or dielectric capability. Solid materials are permanently damaged by an electric breakdown.

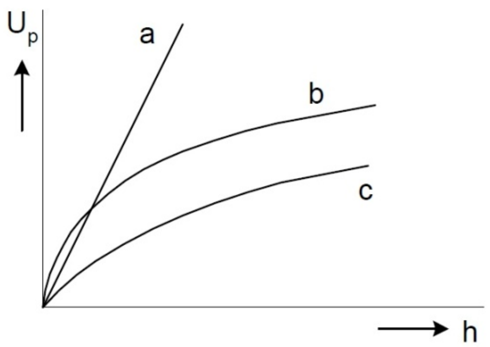
The essence of the electric breakdown is an intense increase in electric conductivity in the material. It is caused by a sudden increase in the concentration of free charge carriers. The electric breakdown proceeds to the electric arc until source shutdown. The damage range depends on the arc action duration, surrounding atmospheric conditions, specimens' material and the value of the passing current. We make a distinction between two electric breakdown types, thermic and purely electric.

The thermal breakdown of solid insulators is evoked by a sudden development of heat evoking an unlimited temperature rise until the critical moment when the insulator is thermally damaged in a particular local place and its insulating capacity drops significantly. Dielectric losses are the source of the heat. Conductivity and loss factor increase by heating the material. If conditions for reliable heat removal to the surroundings are created, the temperature increase stops at a certain level and no breakdown appears.

Dielectric losses can be physically divided into:

- **Conductance losses** occur in all insulators because they all contain a certain number of free electrical charges and their movement at AC or DC voltage is linked with the transformation of electrical energy into heat.
- **Polarization losses** are caused by a delay-bound movement of electrical charges for changing the size of the electrical field intensity. Here some of the energy obtained from an electrical field stays in the form of kinetic energy and transfers it to the neutral particles of material which are causing heat generation.
- **Ionization losses** occur in the gas cavities of solid insulators when the voltage is higher than the gas ionization voltage.
- **Pure electric** breakdown is the result of the interaction of electrons occurring in the material with the present electrical field. Electrons gain energy from the electrical field during their free electron path. This energy is transferred to the material when the material brakes the movement of the electrons. If this process of energy increase is higher than the energy decrement, a pure electric breakdown appears. The size of the electrical field Ep intensity in this type of breakdown is independent of the insulator thickness, electrode shape, and also on the voltage waveform over time. This depends especially on the material's structure and atomic composition.

In practice, the electric and thermal breakdowns can occur simultaneously because conditions are created for both the above-described electron process and sufficient heat generation as a consequence of dielectric losses.



$$E_p = \frac{U_p}{h}$$

E_p - Intensity of electric field [V/m]
U_p - Electric strength [V]
h - Distance between electrodes [m]

Figure1: Dependence Up = f (h), formula for calculation Ep.

a) purely electric breakdown, b) thermal breakdown, c) participation of both types of breakdown.

3 DESCRIPTION OF THE MEASURING DEVICE

The measuring device was proposed and constructed specially for this experiment. It was based on knowledge provided by the Czech technical standard ČSN EN 60243-2 – The Electric Strength of Insulation Materials – Experimental Methods – Part 2: Additional requirements for direct tension testing.

3.1 Measuring Stand with High-Speed Camera

The measuring stand was constructed with respect to the properties and parameters of the experimental specimens and the used electrodes. For the accurate detection of the breakdown, we used high-speed camera recording (see fig. 2), which was used for dynamic processes.

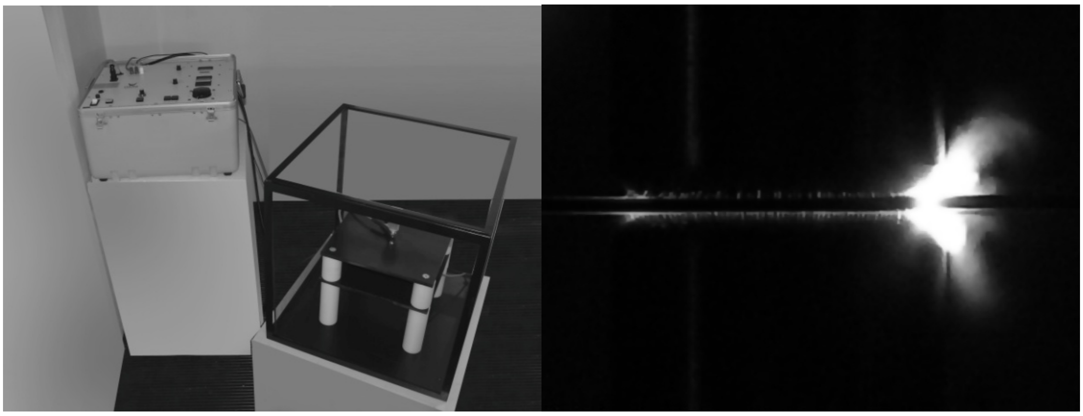


Figure 2: High voltage source and electric strength measuring stand in the left picture, a high speed camera shot of material breakdown in the right picture.

3.2 High Voltage Source – Wiring Scheme

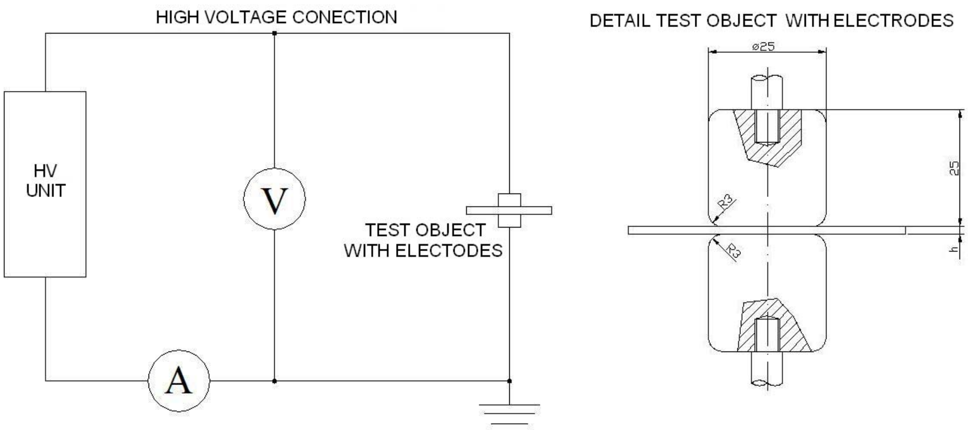
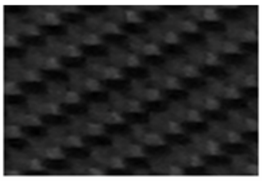
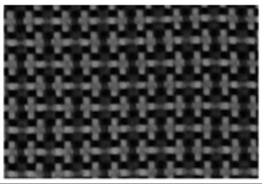


Figure 3: Simplified electrical diagram of measuring stand.

3.3 Specimens

CONSTRUCTION COMPOSITE MATERIALS		
FIBERGLASS		**Composition:** Epoxide resin LH160, hardener H534, 5 x glass fabric 200 g/m^2 cloth. (Dimension 200x200mm)
KEVLAR		**Composition:** Epoxide resin LH160, hardener H534, 5 x kevlar fabric 173 g/m^2. (Dimension 200x200mm)
FIBERGLASS/ KEVLAR		**Composition:** Epoxide resin LH160, hardener H534, 2 x glass fabric 200g/m^2 cloth,3 x kevlar fabric 173 g/m^2. (Dimension 200x200mm)
CARBON		**Composition:** Epoxide resin LH160, hardener H534, 1 x carbon fabric twill 200g/m^2, 2x carbon fabric 300 g/m^2 biaxial. (Dimension 200x200mm)
KEVLAR/ CARBON		**Composition:** Epoxide resin LH160, hardener H534, 5 x fabric kevlar-carbon 165 g/m^2 cloth. (Dimension 200x200mm)

ELECTRIC-ISOLATION COMPOSITE MATERIALS		
KARTIT		Composition: Cellulose paper as support, modificate phenolic bitumen as bond. (Dimension 200x200mm)
TEXTITE		Composition: Cotton cloth as support, phenolic bitumen as bond. (Dimension 200x200mm)
GLASSTEXTITE		Composition: Modified glass fabric as support, epoxide bitumen as bond. (Dimension 200x200mm)

4 RESULTS AND DISCUSSION

Tab. 1 Table of measured and calculated experimental data.

Identification of the material	Sample number	Electric strength [kV/mm]	The thickness of the sample at the Breakdown [mm]	Breakdown voltage [kV]	The median value of electric strength [kV/mm]	Maximum measurement error [kV/mm]
Fiberglass	S 1	50,77	1,31	66,51	49,96	±0,98
	S 2	49,25	1,15	56,63		
	S 3	50,53	1,23	62,15		
	S 4	49,64	1,27	63,05		
	S 5	49,62	1,24	61,53		
Kevlar	SK 1	44,06	1,42	62,57	44,54	±1,32
	SK 2	45,97	1,45	66,65		
	SK 3	43,67	1,42	62,02		
	SK 4	44,32	1,42	62,94		
	SK 5	44,69	1,43	63,91		
Fiberglass/ Kevlar	K 1	46,32	1,39	64,39	46,43	±0,58
	K2	46,38	1,37	63,54		
	K3	45,87	1,38	63,30		
	K4	46,88	1,40	65,63		
	K5	46,71	1,36	63,52		
Glasstextite	ST 1	71,94	1,15	82,73	70,26	±1,88
	ST 2	70,29	1,14	80,13		
	ST 3	70,93	1,18	83,70		
	ST 4	69,33	1,11	76,96		
	ST 5	68,81	1,18	81,20		
Kartit (Pertinax)	0,5 KT 1	27,36	0,53	14,50	28,60	±1,55
	0,5 KT 2	30,00	0,52	15,60		
	0,5 KT 3	28,27	0,52	14,70		
	0,5 KT 4	29,25	0,53	15,50		
	0,5 KT 5	28,11	0,53	14,90		
Textite	T 1	27,19	0,89	24,20	27,33	±0,55
	T 2	27,42	0,92	25,22		
	T 3	26,85	0,93	24,97		
	T 4	27,30	0,91	24,85		
	T 5	27,87	0,91	25,36		
Carbon	U 1	0,00	1,52	0,00	0,00	±0
	U 2	0,00	1,47	0,00		
	U 3	0,00	1,48	0,00		
	U 4	0,00	1,65	0,00		
	U 5	0,00	1,58	0,00		
Kevlar/Carbon	KU 1	0,00	1,57	0,00	0,00	±0
	KU 2	0,00	1,52	0,00		
	KU 3	0,00	1,50	0,00		
	KU 4	0,00	1,55	0,00		
	KU 5	0,00	1,50	0,00		

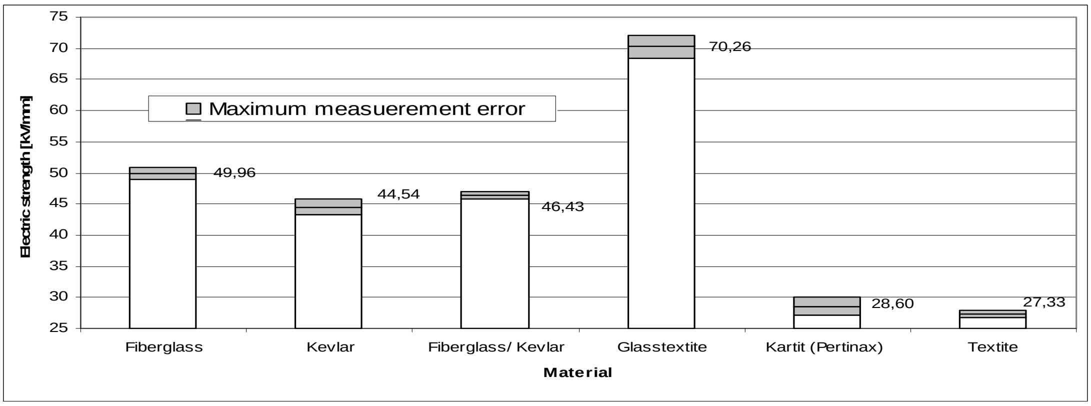


Figure 4: Electric strength diagram.

The results of the experiment lead to several findings. The acceptable materials for the electrical insulating construction parts of the electromobile are the composites Fiberglass, Fiberglass/Kevlar, and Kevlar. These materials have more than 100 percent higher electric strength than the electrical insulation materials Kartit or Textite. Carbon-based composites seem less suitable for non-conducting structures and components. Carbon fiber in composites creates a non-homogenous field of conductible canals. The conductivity of composites with a carbon component is caused by defects in the surface layer of resin and the presence of frayed ends of carbon fibers. These frayed ends extend to the surface of the composite. For this reason, carbon-based composites cannot be recommended for separating strong electrical circuits from the environment.

A significant finding is the analysis of the difference in the electric strength of Fiberglass and Glasstextite. Glasstextite's electric strength is 30 % higher. These materials have a very similar composition and differ especially in the production technology. Glasstextite is created using an industrial technique. The Fiberglass manual creation technology causes the formation of fine gaseous cavities in the composite volume. Ionization occurs in these fine gaseous cavities with a high electrical field. The ionization causes the chemical-thermal transformation of the gaseous state and, in some cases, cavities split and the material is damaged by the outburst of ionized gas. For this reason there is a breakdown of the material at a lower voltage level.

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Cost – Benefit Analysis for the Implementation of Four-arm Roundabouts in Urban Areas

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ABSTRACT: The implementation of a roundabout has a mostly positive effect on the safety level of a treated site. This is based on the fact that the roundabout's geometry reduces the number of collision points, decreases the speed of vehicles, and improves the safety of pedestrians. Within the frame of the ROSEBUD project[1], the cost – benefit analysis for the reconstruction of four-arm intersections into roundabouts has been calculated, and the results confirm that these reconstructions are effective and have positive effects on the reduction of accidents. The article describes this calculation on roundabouts in the Czech Republic.

KEY WORDS: Cost-benefit analysis (CBA), roundabout, accident reduction.

1 INTRODUCTION

In the Czech Republic, about 10% of road accidents occur on four-arm intersections[2] [Summary of Czech accidents data, 2006 - 2009]. One of the measures aiming at reducing the number of these accidents on four-arm intersections is to rebuild the suitable intersections into roundabouts. There are several reasons for implementing the roundabouts: their effects on improving road safety and the capacity or decrease of speed (traffic calming). In some cases the roundabout can also be a significant architectonic element of a city design. The positive effects of properly designed and built roundabout are well known from numerous studies in many countries.

In Czech traffic engineering, roundabouts are still quite a new design element. There still exists some mistrust about their use. Nevertheless, the number of roundabouts in the Czech infrastructure network has significantly increased in the few last years.

There is lack of available data and studies evaluating the safety performance of roundabouts in the Czech Republic. One of the rare sources of information is the BESIDIDO project[3]. The accident data used in the cost-benefit analysis described below are based mainly on findings from the BESIDIDO project. The methodology of the CBA calculation was prepared in the ROSEBUD project.

1 ROSEBUD is a thematic network funded by the European Commission to support users at all levels of government (European Union, national, regional, local) with road safety related efficiency assessment solutions for the widest possible range of measures. Project deliverables can be found here - http://partnet.vtt.fi/rosebud/.

2 In 2009, seventy fatalities were reported in these accidents. The data are both for urban and rural roads.

3 Research project funded by the Ministry of Transport and elaborated on by CDV and Czech Technical University in Prague. Project finished in 2004 and aimed at evaluating the safety effects of various infrastructure measures.

2 DESCRIPTION OF THE SAMPLE

There are eight roundabouts in the evaluated sample. The availability of relevant data and the similarity in the roundabout's design elements were the main criteria for their selection. All of them are four-arm roundabouts which were constructed between the years 1998–2002 instead of four-arm intersections in urban areas in cities with a population of less than 70 000 inhabitants.

Figure1: Examples of roundabouts in the sample. On the left –Lázně Bohdaneč; on the right – Ždírec, (source: project Besidido, 2004).

A brief description of the sample is shown in Table 1.

Table 1: Description of the sample (source: project Besidido, 2004).

Site number. City	Population	" Before" accident data	Year of implementation	"After" accident data
1.Česká Lípa	40 000	1995-1997	1998	1999-2000
2.Chlumec nad Cidlinou	5 000	2000	2002	2003
3.Chrudim	25 000	2000-2001	2002	2003
4.Lázně Bohdaneč	3 500	2000-2002	2003	2004
5.Litomyšl	10 000	1999 - 2000	2001	2002
6.Most	70 000	1999	2000	2001-2003
7.Tábor	37 000	1996-1997	1998	1999-2000
8.Ždírec	3 000	2000-2001	2002	2003-2004

All roundabouts in the sample are "typical" four–arm roundabouts[4] designed in accordance with the Czech technical standards. The reason for their implementation was mainly a demand for more capacity and for improving the safety situation.

2.1 Target group of accidents

The implementation of a roundabout has a mostly positive effect on the safety level of the treated site. This is based on the fact that the roundabout's geometry reduces

[4] "Typical" means a roundabout with a one traffic circulatory lane, one-lane entrance and exit, the diameter of the roundabout is up to 35m.

the number of collision points, decreases the speed of vehicles, and improves the safety of pedestrians. The only negative phenomena could be the lower safety level for cyclists, but only in some cases (e.g., an unsuitable design of cycle facilities). Therefore, the target accident group was defined as “all accidents occurring on the treated sites”.

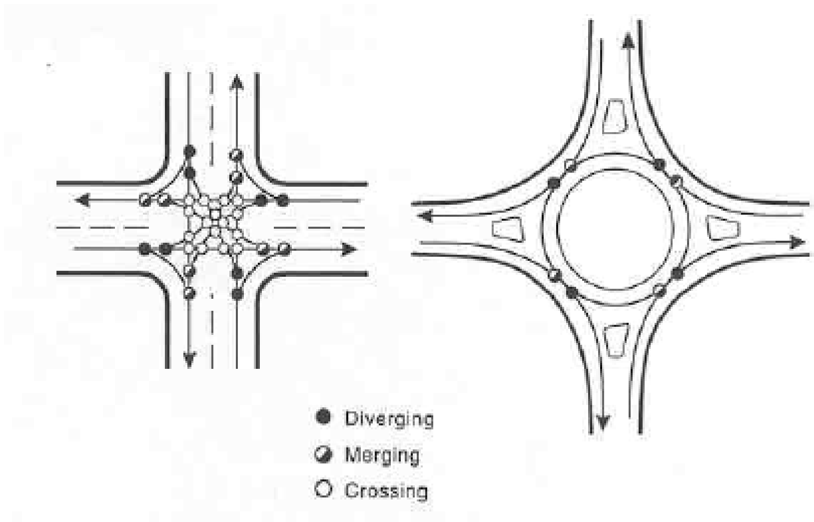

Figure2: Comparison of no. of collision points on a four-arm intersection and roundabout.

The sample contains eight sites where the original four-arm intersections without traffic lights were rebuilt into four-arm roundabouts. Based on accident data before the implementation of the roundabouts, an “average” intersection accident was determined. This is an accident with 0.004 fatality, 0.04 severely injured, 0.19 slightly injured, and with property damage valued at 27 000,-CZK. The value (socio-economy loss) of one average accident is calculated to be around 7 500,- € (at 2002 prices[5]), based on the methodology of an accident’s cost used in CDV.

3 ASSESSMENT METHOD

The ideal method of assessment would be to conduct a complete CBA (with a calculation of roundabout effects not only for safety performance, but also for the environment and mobility). The quality of available data did not allow for such a complete analysis, so only the safety effects were calculated in the analysis.

The suitable method for such a calculation is a method combining an after/before comparison with a control group of sites (sites which are similar in most characteristics to the treatment sites but left untreated). In this calculation, the total number of accidents on four-arm urban intersections in the whole country was used as a control group, so that the general trends in the development of accident numbers are taking into consideration.

The aim of the calculation was to find the number of accidents prevented through the implementation of roundabouts on eight sites. The “before” and “after” accident data for the treated sites and for all four-arm intersections in the Czech Republic were known.

An evaluation of the treatment effect θ_i, at each site, by means of the Odds-ratio with the comparison group, was calculated. A correction due to changes in the traffic volumes is not performed, so $\delta = 1$. The formula has the form:

[5] This would be cca 12 000,- € at 2009 prices

$$Estimated\ effect(\theta) = \frac{X_a}{X_m \frac{C_a}{C_b}} \delta$$

where

X_a – the number of accidents observed at the treatment site in the “after” period,

X_m – the number of accidents at the treatment site in the “before” period,

C_a – the number of accidents in comparison group sites in the “after” period,

C_b – the number of accidents in comparison group sites in the “before” period.

Weighting the effects found for separate treatment sites is done by means of the standard method for weighting Odds-ratios, where a statistical weight of a separate result is defined by the sizes of data sets, which provided this result:

$$Weighted\ mean\ effect(WME) = \exp\left(\frac{\sum_i w_i \ln(\theta_i)}{\sum_i w_i}\right)$$

$$w_i = \frac{1}{VAR(\log(\theta_i))} = \frac{1}{\frac{1}{X^i{}_a} + \frac{1}{X^i{}_b} + \frac{1}{C^i{}_a} + \frac{1}{C^i{}_b}}$$

where

θ_i - estimate of effect for site i,

w_i - statistical weight of estimate for site i,

$X^i{}_a$ – the number of accidents observed at treatment site i, in the “after” period,

$X^i{}_b$ – the number of accidents at treatment site i, in the “before” period,

$C^i{}_a$ – the number of accidents in comparison group (for site i), in the “after” period,

$C^i{}_b$ – the number of accidents in comparison group (for site i), in the “before” period.

The 95% confidence interval for the weighed effect is estimated as follows:

$$\left(WME \exp\left(\frac{z_{\frac{\alpha}{2}}}{\sqrt{\sum_i w_i}}\right), WME \exp\left(\frac{z_{1-\frac{\alpha}{2}}}{\sqrt{\sum_i w_i}}\right) \right)$$

The applicable value of the safety effect, i.e., the best estimate of accident reduction associated with the treatment (in percent), is calculated as (1-WME)*100.

4 ASSESSMENT QUANTIFICATION

4.1 The unit of implementation, the discount rate and price of a typical accident

A four-arm roundabout was determined to be the typical unit of implementation. The typical implementation cost was estimated to be 300 000,- € (at 2002 prices). The estimate was based on results found in the BESIDIDO project. The cost of maintenance was not calculated, due to an assumption that the cost of maintenance is similar for four-arm intersection as it is for the four-arm roundabout. The duration of the effect was estimated to be 20 years.

The discount rate was determined to be 5%. This is based on the recommended value of the discount rate used in the Rosebud project. All prices are converted into Euro, the price level is as of the year 2002. The price of a typical four-arm intersection accident was calculated to be 7 500, - € (at 2002 prices). The calculation is based on the accident statistics of the intersections from the sample before the implementation of roundabouts.

4.2 Safety effect

The aim was to find the number of accidents which were prevented through the implementation of roundabouts instead of four-arm intersections in an evaluated sample of eight sites.

Table 2: Data for calculations.

site number	site accidents		comparison group		estimated effect θ_i	statistical weight of estimate w_i
	before	after	before	after		
1	85	24	57810	34356	0.475	18.699
2	5	5	17409	16695	1.04	2.5
3	36	3	34135	16695	0.17	2.768
4	13	5	50861	16600	1.178	3.61
5	2	1	34356	16726	1.027	0.666
6	10	4	16947	50147	0.135	1.428
7	27	29	38810	34356	1.213	13.971
8	19	1	34135	33295	0.054	0.949

Table 3: Safety effect of evaluated roundabouts.

Estimated effect (WME)	WME confidence interval	Number of treatment sites in the sample	Number of accidents at the treatment sites
0.624	(0.465, 0.836)	8	197

The average accident reduction associated with the treatment was calculated as (1-WME) x100 = (1- 0.624) x 100 = **37.6%.**

Table 4: Accident reduction.

Site number	Average annual no. of accidents	Reduction of accidents
1	28.3	10.64
2	5	1.88
3	18	6.77
4	4.3	1.62
5	1	0.37
6	10	3.76
7	13.5	5.08
8	9.5	3.57

Total no. of saved accidents: 33.7.

The total sum of accidents saved annually multiplied by the average accident costs (the total benefit) is 33.7 x 7 500 = 253 000,- €. The annual average sum of money saved for one treated site is 31 625,- €.

5 ASSESSMENT RESULTS

The total cost of prevented accidents in a period of 20 years on one treated site is calculated to be 444 000,- €. Because the cost of one unit of implementation is estimated 300 000,-€, the cost/benefit ratio is 1/1.5.

Table 5: Costs and benefits – 20 years period.

Accident saved	444 000,-€
Cost of 1 unit	300 000,-€
Cost / benefit	**1/ 1.5**

6 CONCLUSION

Due to the limited sources of available data it was not possible to calculate a complete CBA. A "mini-CBA" was thus calculated - only the safety effects of roundabouts were taken into account. The effects on environment and mobility were not taken into account. The result showed that the four-arms roundabouts in urban areas have a positive effect (-37.6%) on the reduction of the number of all accidents.

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Geographical Location of Depopulation Areas in the Czech Republic and its Dependence on Transport Infrastructure

Part I: Definition, Methodology, and Quantitative Analysis

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ABSTRACT: Location of settlement at important routes of transport was always one of the key factors for its prosperity. However, in the car-oriented world of today the distance factor is not so important for many people and they prefer to live in calm rural areas. Simultaneously, many rural areas in peripheral locations are affected by the emigration of inhabitants and global decay. This study explains how good transport infrastructure should be beneficial for rural areas and how it is in reality in the Czech Republic. The study is a part of a larger work of research, based on component analysis of localization of depopulation areas in the Czech Republic between the years 1869 – 2010. The role of transport is documented not only by the localization of the transport infrastructure, but also by the duration and orientation of commuting to work. Theories and premises are supported by quantitative analysis in all municipalities in the Czech Republic and also by three in-depth case studies, oriented more on qualitative indicators.

KEY WORDS: Transport geography, regional development, depopulation areas, transport infrastructure, mobility.

1 INTRODUCTION

One of the burning problems of current European society is the uneven growth of regions connected with the concentration of development to central areas and the decline of remote, marginal areas. The economy of declining marginal regions is heavily supported by subsidies from development funds, but these costly measures often do not ensure the expected benefits. Marginalization of these regions is a complex social phenomenon related to changes in the lifestyle of the society, as well as to demographic changes, which are only handled with difficulties.

Since this phenomenon is, to a large extent, influenced by geographical characteristics, particularly the parameters of distance and the transport accessibility of these regions from centres, a question arises how transport and transport infrastructure influence such a phenomenon and how they may change it. Factors of economic- and time-demanding commuting to work, accessibility, frequency and quality of public transport, and the density and quality of roads are all factors greatly affecting the everyday reality of life in rural areas. How are then these factors affecting the attractiveness and unattractiveness of a given village or a region? This article aims to answer this question.

2 MARGINALIZATION AND DEPOPULATION IN RURAL AREAS

Marginalization is a phenomenon related to the economic decline of a certain area with a simultaneous decline in the importance of this area for economic and social activities, which lead to its loss of attractiveness as a place of residence or a recreation area (see Drápela, 2010). Marginalization is manifested in many spheres, and Leimgruber (2004) considers the economic, socio-cultural, political, and environmental marginality as crucial. In real life, the developing process of marginalization is manifested in the loss of population in exposed areas, when this loss is caused by both the negative balance of migration, and the natural decrease of population due to population ageing.

The reasons for the marginalization of certain areas are explained differently, e.g., Galante and Sala (1987) maintain, that the marginalization is caused by some certain disadvantages of these regions, taking into account different indicators, which subsequently make them uncompetitive. Andreoli (1992) and Schmidt (1998) then search for the reasons of marginalization in insufficient integration into structures, processes, and systems which are dominant in a given place and time. The position outside the dominating structures and systems is considered in the theory of mainstream (Giddens, 1984), which states that marginalization affects those units which are different from the majority in crucial parameters. Tykkyläinen (1998) then understands the marginalized area as a borderline area of socio-economic activity, i.e., at the edge of the socio-economic system. Mehretu et al. (2002) claim that marginalization may be caused by more different causes, while they distinguish:

- contingent marginality, which is a result of a free market with equal competition, when the negative results of the competition come from competition inequality.
- systemic marginality, effective mainly in totalitarian systems where the hegemonic powers of political and economic apparatus bring about discrepancies in the distribution of social, political, and economic benefits.
- collateral marginality, originating as an unexpected side effect of the process. It is a type of a neighbouring effect, when a member of the majority may be unintentionally marginalized for its closeness to a marginal minority.
- leveraged marginality, which is a result of an intentional process, when the pressure applied by economic players, requiring the highest profits and lowest costs, leads to marginalization.

Whatever reasons for marginalization in a given area, the typical result of this process is the depopulation of the given area (Drápela, 2010). In addition, the gradual loss of population subsequently intensifies the marginalization of such a region and generates other problems caused by the ever decreasing population density. This snowball effect may cause a long-term problematic situation, when such depopulated areas are only attractive concerning inexpensive residency, which attracts particularly underprivileged inhabitants, who in turn have difficulties in finding jobs due to their lower qualification. Therefore, marginalized areas may become regions with low population density with a predominantly underprivileged population and with a poor selection of jobs. To ensure this vision may not come true, it is necessary to reveal the marginalization of a region sufficiently in advance and prevent the depopulation of affected disadvantaged areas.

3 METHODOLOGY

Before introducing the methods used in this study, it is essential to specify more closely the research goals. Although in a dissertation (Drápela, 2010), which was a model for this article, the number of objectives was higher, this article focuses on:

1. delimitating depopulated areas in the Czech Republic in the post-communist era,
2. assessing the significance of the impact of transport infrastructure and commuting times on the current distribution of depopulated areas, and,
3. assessing the significance of transport for the development of marginal areas in the long-term perspective.

The first point includes an indicator of population movement (or the total growth or decrease of a population within an administration unit), where the administration unit used for the analysis was selected to be a municipality, of which there are 6 251 in the Czech Republic. The level of municipalities was selected since it is the most detailed reasonable level on which it is still possible to evaluate quantitatively expressed population growth or decrease. Data would still be available for the level of municipal parts; however, some municipal parts have fewer than 10 inhabitants and thus each small change would have a huge effect in comparison with other values. Therefore, at one step higher level, the municipality was chosen.

The values of the indicator were compared for the decades between individual censuses, taking place in the monitored period in 1991 and 2001; the up-to-date census takes place in March 2011. However, the final from the latest census will only be presented in the following years. The data from the census of people, flats and houses were used for 1991 and 2001, whereas the continuous population evidence was used for 2010. The values of the indicator population movement were assessed in such way that a decrease of population in these decades by more than 15 % was considered as “serious marginalization”, a decrease of 5 – 15 % as “important marginalization”, and a decrease below 5 % as “mild marginalization”. The last mentioned category was not paid so much attention, since, due to generation changes in municipalities, temporary changes of permanent residency of inhabitants, and temporary declines caused by migration, smaller municipalities may easily fall into this category while being virtually non-marginalized.

The other objective, the assessment of the significance of the impact of transport infrastructure and commuting times on the current distribution of depopulated areas, became the initial point for a correlation analysis supplemented by case studies results executed in selected depopulated areas at an even more detailed scale and supported by a socio-geographical survey among the population. The correlation analysis was executed based on data from the census in 2001 and the population movement indicator values were compared with the values of the 17 most relevant indicators concerning education, population size of municipalities, population age structure, employment and unemployment, economic activity, commuting and its time terms. The complete list of indicators is specified in the corresponding chapter.

The correlation analysis results were then compared with qualitative data collected with questionnaire surveys in selected model areas, and with historical and geographical research, which are focused on finding impulses having significantly influenced the development of towns and villages in these regions in the past, regardless of whether positively or negatively. Taking into account the size of the article, it is impossible to present the complete methodology of the qualitative research. Nevertheless, it will be briefly outlined. The case studies were performed in model areas of the Nové Město region, due to its location representing mountain and foothill regions; the Litenčice region, due to its location representing richer agricultural regions; and the Pelhřimov region, for its special historical development when virtually the whole region was the property of one owner, the order of Premonstratensians, representing a region with a long-term planned population structure.

The questionnaire survey was executed in the above-mentioned model areas with a sample of 100 inhabitants. The questionnaire was focused on both the subjective assessment of transport infrastructure in a given locality, while its objective was to understand the inhabitants' perception and preferences, and the real transport behaviour of the inhabitants, where its structure was very similar to a typical travel survey. In the first part of the survey people answered questions concerning their subjective assessment of the quality and density of the transport infrastructure in the place of their residence, localities which they view as a potential threat to their safety concerning traffic, their preferences and reasons when choosing a mode of transport, satisfaction with public transport services, their quality, routes, frequency and prices; the final open question concerned their recommendations for the further development of transport and transport networks in the locality. The main outcome of this part was a SWOT analysis of the transport situation in the area. The other part of the questionnaire was used as an improvised travel survey when the respondents answered questions concerning their real spatial mobility: why, where, how often, by which transport means, how long, how far, and which way they travel. Subsequently, based on these data, it was possible for each region to compile a set of schemes of a given municipality inhabitants' spatial mobility, which supplements the SWOT analysis based on subjective impressions with an objective perspective.

The results of the historical and geographical research were only marginally used, which were otherwise a substantial part of the dissertation, since it focused rather on different factors, particularly the physio-geographical, ownership, historical, socio-cultural, economic, environmental, or a factor of externalities impact. Within this research, with the use of historical sources, the development of municipalities in model areas from the date of the origin (e.g., already from the 11th century) until today was analysed: number of inhabitants and houses, records of economic activities, rights and privileges, disasters, and intentions of owners-feudalist, etc. up to civic amenities, political decisions having a direct impact on given localities, and public transport. These data were then subjected to a critical assessment of their impact on the development or decline of these municipalities, and the impact of individual factors is illustrated in examples. Regarding the factor of transport, the last 200 years, related to the industrialization and the development of a road and railway network, are taken into account.

4 DEPOPULATION AREAS DEFINITION

As mentioned in the previous chapter, the definition of a depopulation area, i.e., an area with negative values of inhabitant mobility indicators, is completed with threshold values, derived from empirical experience, dividing the set of communities with a decrease of population into three groups: slightly affected by depopulation (a decrease of inhabitants up to 5 %), where this phenomenon is often only of short-term dimensions; significantly affected by depopulation (a decrease of inhabitants between 5 – 15 %); and considerably affected by depopulation (a decrease of inhabitants over 15 %). Attention should thus be aimed at the two latter categories and at their relation to the spatial distribution of main roads.

The situation between 1991 and 2001 is depicted in Figure 1, the period between 2001 and 2010 in Figure 2. The black colour represents the main urban agglomerations, where the most important are Prague agglomeration, with about 1.5 million of inhabitants, Brno and Ostrava agglomerations, each with 0.5 million of inhabitants. The various shades of grey indicate the population rate.

The Figures show that the spatial distribution of depopulation areas in the Czech Republic depends especially on the distances of these regions from centres. The depopulation areas create something like rings around the main centres, interrupted only at locations where the big centres are not far away from one another. Within this phenomenon, there cannot be seen a considerable influence of the proximity to main roads (e.g., especially motorways) as a factor significantly preventing depopulation. If a road runs in the proximity of a depopulation area, but the communities in direct proximity to the road do not suffer from a decrease of inhabitants it is rather caused by a different land relief, where the road runs through lowlands, whereas the depopulation area is situated in a highland or mountain terrain. In a situation of comparable orographic conditions in areas directly around the road as well as ones farther from it, its positive influence on depopulation is usually not applied. On the contrary, outside these depopulation areas, in areas closer to centres, there exist isolated depopulation units or their clusters that differ from their prosperous surroundings by lower residence attractiveness, which is often caused, besides other reasons, by worse accessibility to the centres, i.e., by parameters of transport network. The transportation factor is thus manifested relatively significantly within the competition between individual communities. However, with regard to the intraregional aspect, the rural areas represent a relatively homogenous area.

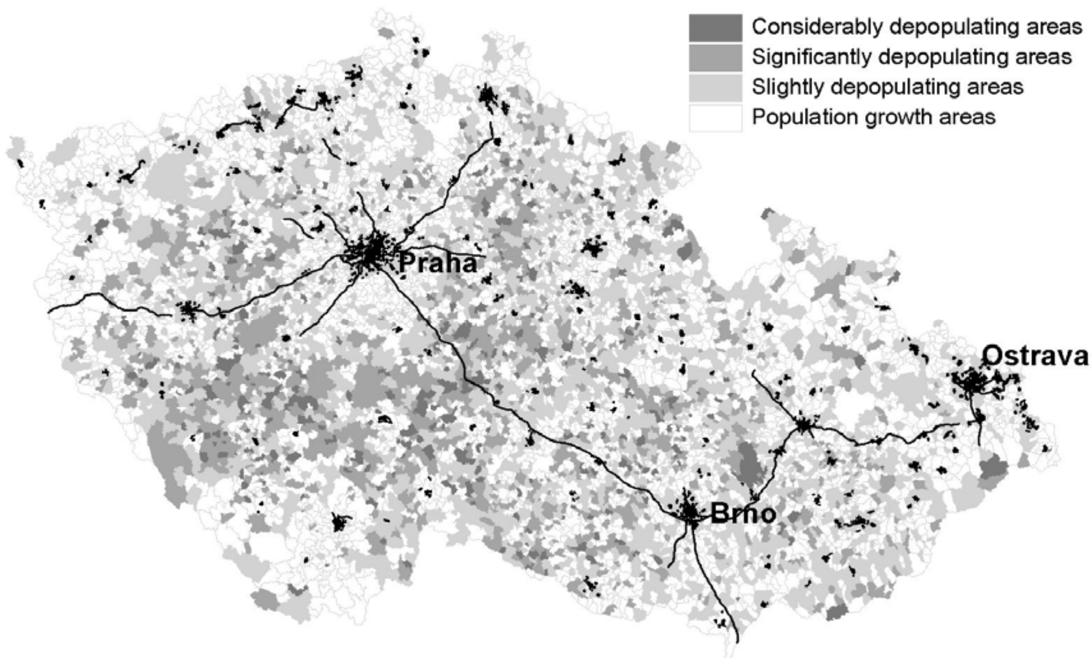

Figure 1: Depopulation areas in the Czech Republic between 1991 and 2001 and their relation to spatial distribution of main roads.

By comparing particular time periods (the survey in the background thesis started already in 1869 with the first population census executed for the Habsburgs' Austrian Empire) we may conclude that both Figures differ mainly by the intensity of continuing depopulation. This is caused by demographical trends going on within the Czech population, where the period between 1991 and 2001 was a period of historically lowest population growths, while the period between 2001 and 2010 was a time period when the population strong age groups from the 70s of the 20th century were starting to establish families. What is important, though, is that the spatial allocation of depopulation areas has not changed significantly, which can be seen even after comparing data older than 100 years (see Drápela, 2010). The problems of these regions are apparently of a long term character, which is a considerable finding.

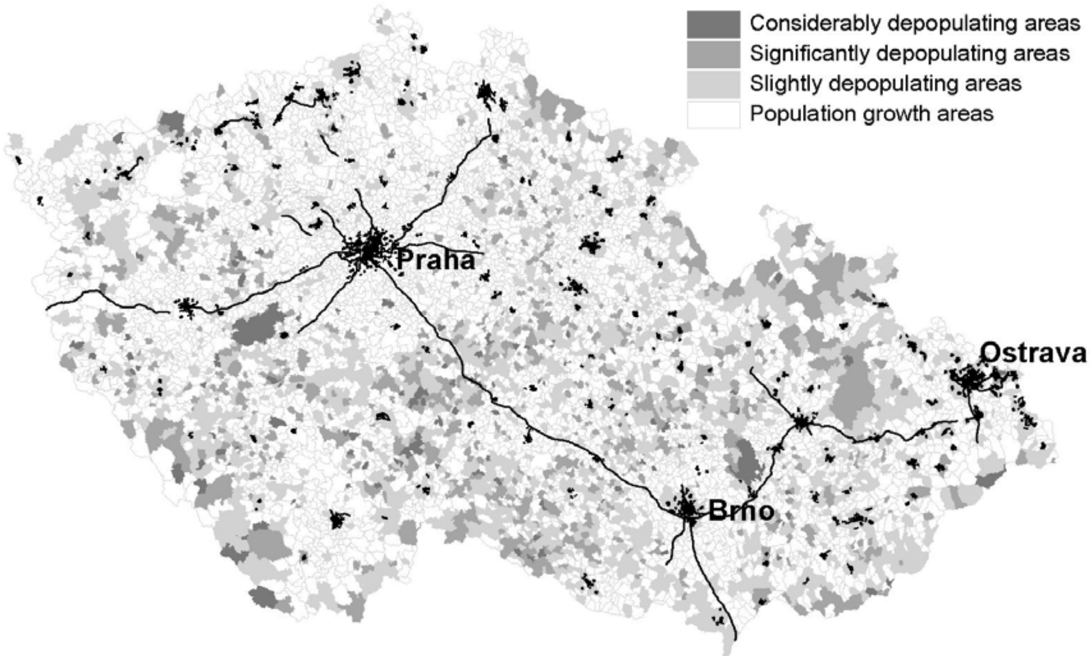

Figure 2: Depopulation areas in the Czech Republic between 2001 and 2010 and their relation to spatial distribution of main roads.

5 CORRELATION ANALYSIS

The complex character of marginalization, manifested by depopulation, results in the impossibility to definitely mark a factor or a group of factors as a cause of the phenomenon. Various factors are mutually interlaced and it is frequently impossible to separate the effects of one factor from another. For example, the land relief and the watercourse network in upland areas often affect the centrality of such location, the leading of main roads, fertility of soil and suchlike. Economic, social, and demographic factors are similarly interwoven. This is why the analysis is focused on revealing the typical features of depopulation areas and it does not judge, for the time being, what is the cause and what is the consequence. The research method applied was a classic correlation and regression (not mentioned in this paper focused only on transport issues), where, in regard to the character of the phenomenon and to the fact that only the similarity of division is studied and not the mutual dependence of variables, indicators with a Pearson correlation coefficient value ±0.3 were assessed as significantly similar. The following 17 indicators (in the brackets their abbreviations as used in Table 1) have been selected for the analysis:

- the average age of community inhabitants (AverAge),
- proportion of inhabitants aged 0 – 14 of the total number of inhabitants (Inhab_0-14),
- proportion of inhabitants aged 65 and more of the total number of inhabitants (Inhab_65+),
- proportion of inhabitants aged 15 and more with a completed university degree of the total number of inhabitants (Prop_UNI),
- proportion of inhabitants aged 15 and more with a completed university degree, higher technical school or secondary school with maturita (school leaving exam) of the total number of inhabitants aged 15 and more (UNI.HTS.SSm),
- proportion of inhabitants aged 15 and more with elementary or uncompleted elementary education, or with no education of the total number of inhabitants aged 15 and more (EL+without),
- number of inhabitants (InhabNum),
- proportion of persons economically active of the total number of inhabitants (Prop_EA),
- proportion of employed persons of the total number of economically active persons (PropEmp),
- proportion of unemployed persons of the total number of economically active persons (PropUnemp),
- proportion of employers and self-employed persons of the total number of economically active persons (Prop_SelfEmp),
- proportion of economically active persons working in primary sector of the total number of economically active persons (Primer),
- proportion of economically active persons working in tertiary sector of the total number of economically active persons (Tertiar),
- proportion of persons commuting daily to work outside the community from the total number of employed persons (ComDaily),
- proportion of persons commuting out of the district from the total number of employed persons (ComOutDis),
- proportion of persons whose commuting time is 30 min and more of the total number of employed persons (ComTime30+),
- proportion of persons whose commuting time is 60 min and more of the total number of employed persons (ComTime60+).

The results of correlation analysis for individual indicators are shown in Table 1.

Table 1: The values of Pearson correlation coefficients for used indicators and p-values (two tailed probability)

AverAge	-0.43383	0.000000
Inhab_65+	-0.40756	0.000000
Primer	-0.35877	0.000000
EL+without	-0.30840	0.000000
PropUnemp	-0.01534	0.476987
InhabNum	-0.00746	0.739996
ComDaily	0.06532	0.001942
ComTime60+	0.14634	0.000000
ComTime30+	0.15778	0.000000
ComOutDis	0.16705	0.000000
Prop_SelfEmp	0.19317	0.000000
PropEmp	0.20533	0.000000
Prop_EA	0.22204	0.000000
UNI.HTS.SSm	0.29196	0.000000
Prop_UNI	0.33077	0.000000
Tercier	0.36619	0.000000
Inhab_0-14	0.38413	0.000000

Table 1 implies that the most significant features of depopulation are the age structure of inhabitants, branch structure of economy in these areas and education level of inhabitants. The age structure of inhabitants was represented by the following indicators: AverAge (correlation coefficient value -0.43), Inhab_65+ (-0.41) and Inhab_0-14 (0.38). The Pearson correlation coefficient values imply that in the Czech Republic depopulation areas the average age of inhabitants is much higher than in other areas, as well as the proportion of inhabitants at a post-productive age, whereas the proportion of inhabitants at a pre-productive age is significantly lower here. This fact, however, also arises from the characteristics of the inhabitant mobility indicator, formed by mechanical, as well as natural, inhabitant mobility.

The group of indicators reflecting the branch composition of economy is represented by the following indicators: Tertiar (0.37) and Primer (-0.36). Depopulation areas are characterized by a high proportion of employed persons working in agriculture, forestry, and fishing, and, on the contrary, by a low proportion of employed inhabitants working in various branches of services.

The last significantly manifesting group of factors is the education level of inhabitants, represented by the following factors: Prop_UNI (0.33), EL+without (-0.31) and UNI.HTS.SSm (0.29). In depopulation areas there is a lower proportion of inhabitants with higher education levels (especially inhabitants with a completed university degree), and, on the contrary, a higher proportion of inhabitants with lower levels of education or even without any.

We could consider the values of indicators Prop_EA, Prop_Emp and Prop_SelfEmp as showing weak similarities, while the remaining indicators reach values too near to zero to be considered as manifested in any way in depopulation. Somewhat surprisingly, the transportation indicators related to commuting are among them. The ComOutDis indicator shows the highest correlation coefficient values, which is not surprising as these areas are often situated near administrative boundaries. Commuting behind the boundaries is thus not more time consuming than commuting to a community within the territory of their own district. The time taken by commuting to work is also practically the same as in the areas with a growing number of inhabitants. It can be said that the parameters of commuting from depopulation areas do not differ in any way from the rest of the country. On the contrary, it can be assumed that depopulation areas are less attractive for their inhabitants because of the low number of well-paid job opportunities in perspective branches (see Tertiar, Primer), which causes the drift of educated people towards the centres (see Prop_EDU, ELZS+without) and with regard to the fact that the more educated are mostly young people, the population of such areas gets older (see AverAge, Inhab_65+), and, accordingly, depopulated.

To be continued in next issue.

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Technical Note on Congress on Electromobility, Prague, May 12 - 13, 2011

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The 1st International Congress aimed at the problems of electromobility took place at the Czech Technical University in Prague. The venue for this event was the new building of the National Technical Library. The main organizers were the Czech Technical University, and the Faculty of Transportation Sciences, in cooperation with the ITS&S organization.

The rich program contained many contributions from different specializations related to electromobility and electromobiles. Detailed information is available at: www.eletromobility.cz.

The Škoda-Auto a.s. company was one of the congress partners and exhibited the Octavia Green E-car powered by an electric engine for the first time in the Czech Republic. This event attracted great interest, as well as the talks by Mr. Petr Kristl on the “New conditions, facts and challenges in the e-car development process” presented during the “Electrovehicle design” session. The congress participants appreciated the philosophy of electric car development aimed at high value for the customers, as well as maintaining attention to the safety levels. The presented overview of the technical steps and questions is a strong motivation for further technical development, and a big effort of the research teams and students projects is expected in the field of electric cars design. The speaker presented the VW concern’s support of the new types of drive systems with the target zero emissions mobility. Electromobility is becoming a leading topic for our biggest car producer which utilizes modern trends in automotive design.

The technical data of the displayed Škoda Octavia Green E-car include information about the type (lithium-ion), mass (315kg) and position of the traction accumulators, brake recovery system, engine power (60 kW), and vehicle range (150 km). The roof solar cells help to keep the air ventilation in a parked vehicle.

It is necessary to stress that the continuous development of conventional vehicles, their transmissions and propulsion systems, combustion process, car body design, etc., bring with them interesting achievements in both a vehicle's dynamics and in environmental protection. The intelligent systems help to increase the active and passive safety, ride comfort, and to reduce emissions. There are many examples, such as fuel consumption reduction (and, consequently, CO_2 production) for powerful engines achieved by modern technologies and downsizing, automatic transmission (with a high number of gears) with intelligent control, sophisticated suspension systems, and driver comfort functions. The high ride comfort, low noise and vibrations, good interior ventilation and automated air condition, and easy vehicle systems interface supported by sensors are significant contributions to transport safety, due to the higher attention level of the driver.

The combination of electric vehicles and modern vehicle systems based on current or unconventional energy resources (and innovative fuels) bring new challenges for future transport systems. The short-term future shows which segment of road transport is suitable for intensive development in electromobility.

Instructions to the authors

1 GENERAL GUIDELINES

Papers based on accepted abstracts and prepared in accordance to these guidelines are to be submitted through the journal's web site www.transportsciences.org. All papers, using Microsoft Word2000 (or newer) are limited to a size of at least 4 and no more than 8 single-spaced pages on A4 paper size (297 mm X 210 mm), including figures, tables, and references and should have an even number of pages. The paper's top, bottom, right and left margins must be 2.5 cm. No headers, footers and page numbers should be inserted.

2 TITLE, AUTHORS, AFFILIATIONS

The title of the paper must be in title letters, Times New Roman, font size 16, and aligned left. Use more than one line if necessary, but always use single-line spacing (without blank lines). Then, after one blank line, aligned left, type the First Author's name (first the initial of the first name, then the last name). If any of the co-authors have the same affiliation as the first author, add his/her name after an & (or a comma if more names follow). In the following line type the institution details (Name of the institution, City, State/Province, Country and e-mail address of a corresponding author). If there are authors linked to other institutions, after a blank line, repeat this procedure. The authors name must be in Times New Roman, regular, and font size 12. The institution details
must be in Times New Roman, italic, and font size 10.

3 ABSTRACT

The abstract should start after leaving eight blank lines. Type the text of the abstract in one paragraph, after a space behind the word abstract and colon, with a maximum of 250 words in Times New Roman, regular, font size 12, single-spaced, and justified. After leaving one blank line, type KEY WORDS: (capital letters, Times New Roman, font size 12), followed by a maximum of five (5) key words separated by commas. Only the first letter of the first key word should be capitalized.

4 THE TEXT

The main body of the paper follows the key words, after two blank lines (i.e., two blank lines between the first heading and the key words). The body text should be typed in Times New Roman, font size 12 and justified. The first line of the paragraphs should be indented 5 mm except the paragraphs that follow heading or subheading (i.e., the first line of the paragraphs that follow heading or subheading should not be indented). Never use bold and never underline any body text.

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The headings are in capital letters, Times New Roman, font size 12. Subheadings are in title letters Times New Roman, font size 12. The headings and subheadings must be aligned left and should not be indented. Leave two blank lines before and one after the heading. There should be one (1) blank line before and after the subheadings. All headings and subheadings must be numbered. If a heading or subheading falls at the bottom of a page it should be transferred to the top of the next page.

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Figures, line drawings, photographs, tables should be placed in the appropriate location, aligned centre, and positioned close to the citation in the document. They should have a caption, Times New Roman font size 12, with a colon dividing the figure number and the title (Figure 1: Material properties) and should be numbered consecutively, e.g. Figure 1, Figure 2, Table 1, and Table 2.

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At the end of the paper, list all references with the last name of the first author in alphabetical order, underneath the heading REFERENCES, as in the example. The title of the referred publication should be in italic while the rest of the reference description should be in regular letters. References should be typed in Times New Roman font size 12. citation standard ISO 690.

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