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The Context of Transport in the Concept of the Syndromes of Global Change

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ABSTRACT: This contribution aims at outlining the relatively new approach towards the issue of the global changes assessment. Firstly the Concept of the syndromes of global change is presented. This Concept brought a new view to the human-made impacts assessment. The second part of this paper discusses the role of transport in the constituent elements of this Concept. Transport plays an overriding role in development syndromes, primarily in the Urban Sprawl Syndrome.

KEY WORDS: Transport, global change, suburbanization, pollution.

1 INTRODUCTION

There are many factors which shape our environment and human-made impacts play a crucial part at this time. Human activities have always influenced environment but nowadays is the first time when these impacts have a global scale. The anthropogenic climate change is a good example to show the dimension of human-made effects. One of the human activities especially causing climate change is transport. Transport is influenced by economic and social development, but also brings with it a lot of undesirable impacts, such noise and air pollution, etc.

2 CONCEPT OF THE SYNDROMES OF GLOBAL CHANGE

The Concept of the syndromes of global change was developed by the German Advisory Council on Global Change (WGBU) in 1996. Global Change is clearly about to transform the operational mode of the global ecosystem, thereby generating cascades of significant (and possibly irreversible) impacts on the majority of individuals in present and future generations (WGBU, 1996). Firstly, the WGBU described - with force symptoms - the global dynamics with the aspects connected to the civilization – nature interface. Secondly, 16 syndromes were defined within the frame of the Concept divided into three categories (see table 1 (WGBU, 1996)).

The first category covers utilization syndromes, such as over-cultivation, overexploitation, non-sustainable agro-industrial use of soils and environmental destruction. The second category contains development syndromes, for example environmental degradation through uncontrolled urban growth, or the destruction of landscapes through the planned expansion of urban infrastructures. The last category of this Concept includes sink syndromes such as Smokestack Syndrome or Contaminated Land Syndrome.

Table 1: Syndromes of Global Change (WGBU, 1996).

Syndromes	Description
Utilization Syndromes	
Sahel syndrome	Over-cultivation of marginal land
Overexploitation Syndrome	Overexploitation of natural ecosystems
Rural Exodus Syndrome	Environmental degradation through abandonment of traditional agricultural practices
Dust Bowl Syndrome	Non-sustainable agro-industrial use of soils and bodies of water
Katanga Syndrome	Environmental degradation through depletion of non-renewable resources
Mass Tourism Syndrome	Development and destruction of nature for recreational ends
Scorched Earth Syndrome	Environmental destruction through war and military action
Development Syndromes	
Aral Sea Syndrome	Environmental damage of natural landscapes as a result of large-scale projects
Green Revolution Syndrome	Environmental degradation through the introduction of inappropriate farming methods
Asian Tigers Syndrome	Disregard for environmental standards in the course of rapid economic growth
Favela Syndrome	Environmental degradation through uncontrolled urban growth
Urban Sprawl Syndrome	Destruction of landscapes through planned expansion of urban infrastructures
Major Accident Syndrome	Singular anthropogenic environmental disasters with long-term impacts
Sink Syndromes	
Smokestack Syndrome	Environmental degradation through large scale diffusion of long-lived substances
Waste Dumping Syndrome	Environmental degradation through controlled and uncontrolled disposal of waste
Contaminated Land Syndrome	Local contamination of environmental assets at industrial locations

For Global change analysis it is essential to assess not only single syndromes, but also their symptoms and interactions. Symptoms indicate both quantitative and qualitative changes of the Earth System. Interaction shows the connection of syndromes. There are six types of pairing among syndromes. The weakest, but most frequent, form is Coincidence. This form means that syndromes occur simultaneously. A stronger form is Coupling through common symptoms (several syndromes have common symptoms). The next form is Reinforcement. Symptoms could reinforce each other, as well as possibly reinforcing entire syndromes. Syndromes could also be allied through Attenuation or Infection. In the first case, one syndrome can whittle away another – for example, Scorched Earth Syndrome influences Mass Tourism Syndrome. In the second case – Infection - some of the active syndromes could precipitate another syndrome in the same region. The last one of the six forms of pairing is Succession, because syndromes connect with the historical development of the civilization.

3 TRANSPORT WITHIN THE FRAME OF INDIVIDUAL SYNDROMES

Transport, primarily road transport, is one of the symbols of the 20th century. Transport participates to a different extent in all of the syndromes. First of all it is connected to Urban Sprawl Syndrome and Smokestack Syndrome, but transport also impacts other syndromes. For example, transport vehicles used for extensive and indefensible agriculture can cause Rural Exodus Syndrome or Dust Bowl Syndrome. Military transport machines can cause Scorched Earth Syndrome. Also, additional syndromes, such as Asian Tigers Syndrome or Mass Tourism Syndrome, are not possible without transport. For example, the enhancement of the greenhouse effect by air travel is one of the major symptoms of Mass Tourism Syndrome.

The above-mentioned symptoms are the basic units for the description of the syndromes of global change. These symptoms characterize aspects of global dynamics, especially the relationship between civilization and nature. Presently the Concept includes 80 symptoms, for example, terrestrial run-off changes, increasing mobility or tropospheric pollution. Transport affects negatively our environment and participates in different symptoms. Figure 1 shows the connection between symptoms and transport.

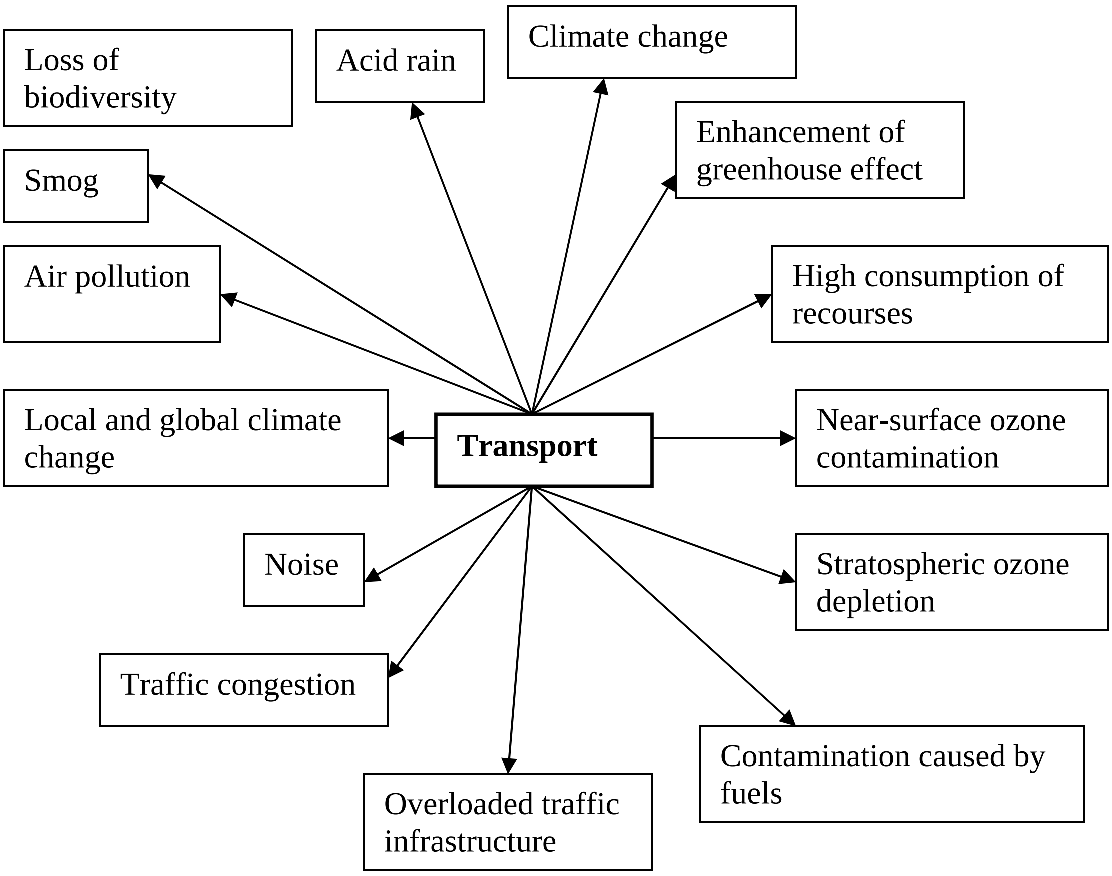

Figure 1: Symptoms and Transport.

Transport has a particularly decisive influence in "Urban Sprawl Syndrome", and "Smokestack Syndrome". This contribution targets these especially. The both syndromes are connected, despite comprising of different groups of syndromes. Urban Sprawl Syndrome, also known as suburban sprawl, represents development syndromes, whereas Smokestack Syndrome represents the group of sink syndromes.

3.1 Urban Sprawl Syndrome

Urban Sprawl Syndrome means the spreading of residential, commercial and industrial zones around large cities, a typical example of which is Los Angeles, but this kind of syndrome begins to be typical also for the Czech Republic.

Urban Sprawl Syndrome contains lot of symptoms (WGBU, 1996):

- Air pollution
- Soil contamination
- Ozone contamination (near-surface and stratospheric)
- Fragmentation of ecosystems
- Acid rain
- Traffic congestion
- Enhanced greenhouse effect

These symptoms are caused largely by transport, a typical example of which is traffic congestion, or urban and air pollution.

One of the indicators of urban sprawl is a low population density. The low population density means a dependence on individual transport, and a dependence on individual transport brings with it a greater impact on the environment, for example, traffic jams or increasing emissions. Many different studies point to the link between petroleum consumption and urban density. For example, a study of more than 30 cities worldwide by Newman and Kenworthy (Newman & Kenworthy, 1989) shows the relationship between petroleum use and average population density (see figure number 2).

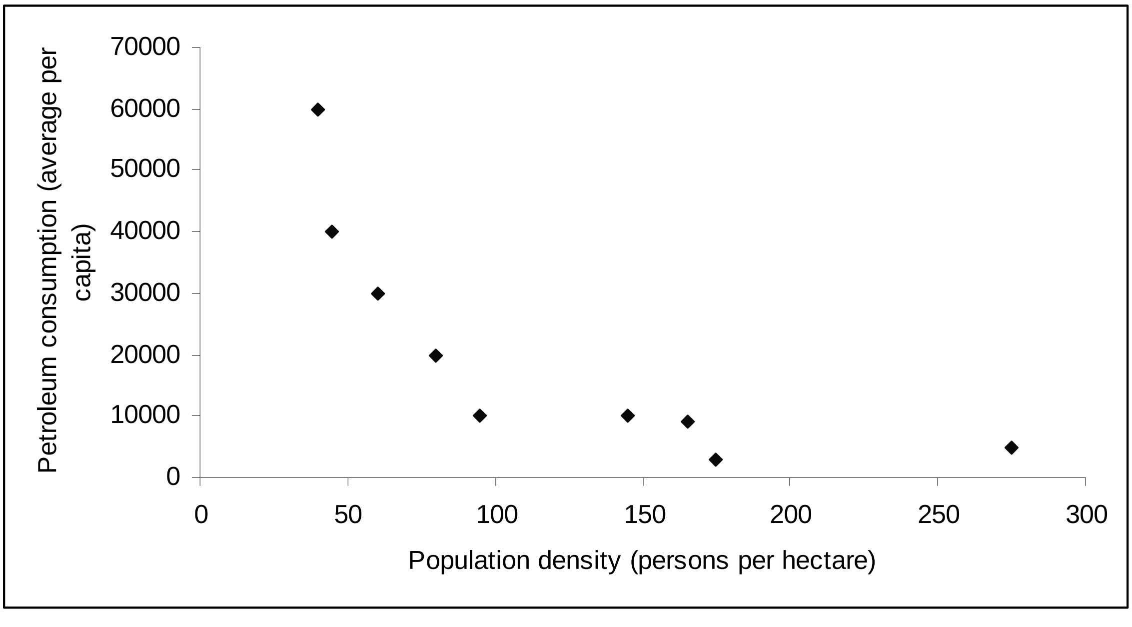

Figure 2: Relationships between petroleum use and average population density (Newman & Kenworthy, 1989).

This graph shows the fact that a low population density results in petroleum consumption rising. North American cities (primarily cities from the U.S.A., such as Los Angeles or Washington) are at the top of this curve. Canadian, and also Australian, cities (such as Toronto or Melbourne) are located below them. European cities (for example, Paris or London) lie in the middle of the graph. Asian cities (Tokyo, Singapore, Hong Kong) are on the bottom of this graph, because the population density is very high in this region.

3.2 Smokestack Syndrome

Smokestack Syndrome means environmental degradation through the large-scale diffusion of long-lived substances. Symptoms of Smokestack Syndrome contain these symptoms (WGBU, 1996):

- Attenuation of the stratospheric ozone
- Loss of biodiversity
- Regional and global climate change
- Sea level increasing
- Increasing of UV-B radiation
- Acid rain
- Contamination of soils and groundwater
- Enhanced greenhouse effect
- Eutrophication of ecosystems

These symptoms are the same as symptoms from Urban Sprawl Syndrome mainly caused by transport, for example, acid rain is a typical representative of regional impacts and an enhanced greenhouse effect is representative of the global impacts of transport on the environment.

According to emissions patterns and the physical-chemical characteristic it is possible to divide this group into three groups of activity. The first one is local, and the typical noxious substance in this group is dust. The second group - regional - creates SO_2, NO_x or NH_3. These pollutants participate in, for example, acid rain. The third group – global – typically CFCs or CO_2, causes global impacts, such as the greenhouse effect, and so on.

While the main sources of air pollution in cities were, in the past, industry and local heating, nowadays it is above all transportation. On the one hand, transportation increases the comfort of city inhabitants; on the other hand, it brings with it many problems – air pollution being one of them. Transport belongs to the significant sources of emissions, and the participation of traffic, primarily road traffic, is considerable. Emissions from transport are included in the all of the three above-mentioned groups. A typical representative of the local group is particulate pollutants. The dust levels represent the negative impact of transportation, particularly in cities. Among the noxious substances from the second group produced by transport belong NO_x. The slightly increasing trend of air pollution by nitrogen oxides is mainly caused by an increasing share of road transportation. The third group transport is included with force CO_2 emissions.

4 CONCLUSION

This contribution presents an interdisciplinary approach to the study of global change. Two of the syndromes that are related to transport are highlighted especially - Urban Sprawl Syndrome and Smokestack Syndrome.

Finally, the coherence between the Concept of the syndromes of global change and crucial environmental issues must be dropped. The graph on the figure 3 shows the link between the wo above-mentioned syndromes – Urban Sprawl Syndrome and Smokestack Syndrome – and core problems with the environment.

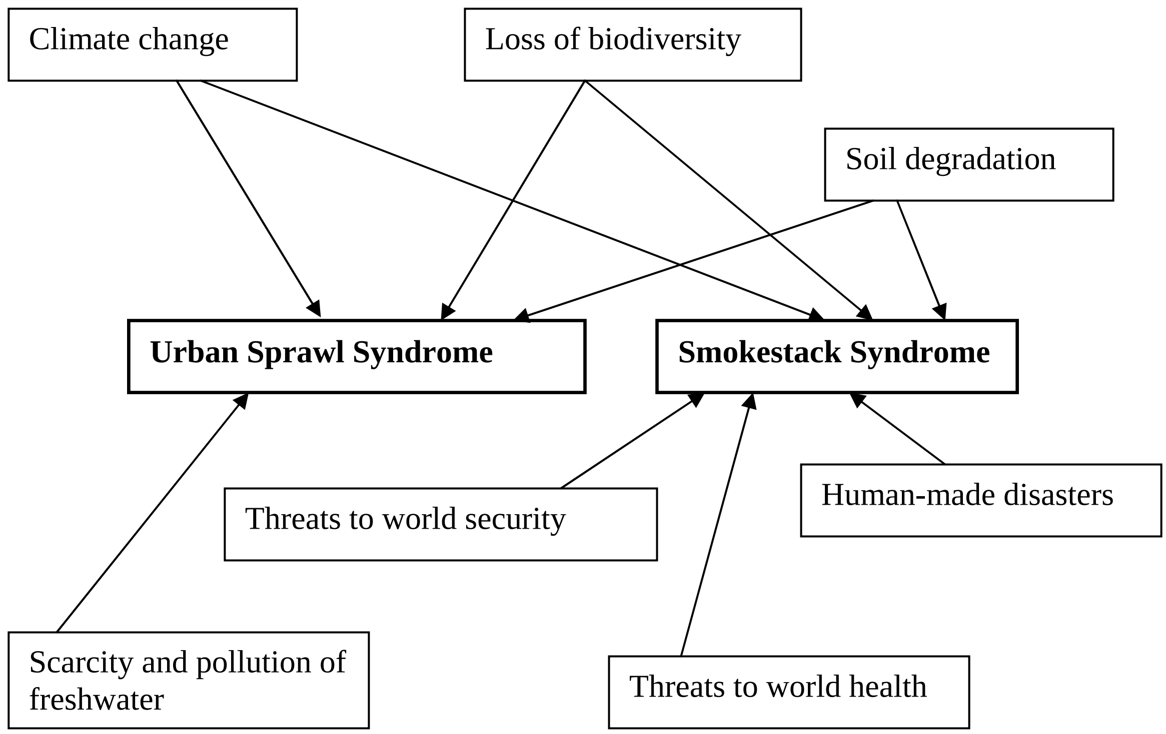

Figure 3: Syndromes and indicators of the core problems of environment (according to WGBU, 1996).

In conclusion is necessary to note that the Concept of the syndromes of global change is not over and research on this theory is still continuing.

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Interaction between Cyclist and Car during Broadside and Confrontation with Pedestrian Throw Formulas – Multibody Simulation

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ABSTRACT: Although the issue of the injury of a cyclist in car collision is in lower when compared to that of pedestrians, we cannot ignore it completely. There is an increasing need to pay attention to bicycle safety due to the growing popularity of motorless single-track vehicles. This study investigates whether it is appropriate to analyze cyclist accidents using relations describing pedestrian throws and whether using simulation software Madymo models the side-impact collision caused by cars. This paper also describes how significant the form of the front parts of normal cars are, as well as the position of the cyclist on three types of bicycles. The analysis of formulas which estimate the car's speed before the impact contributes mainly to the field of judicial expertise and the investigation of car accidents.

KEY WORDS: Biomechanics, cycling, car accident, simulation software, throw distance.

1 INTRODUCTION

The interaction of the human body with a moving car is a significantly highlighted problem of biomechanics that has been intensely studied at many important institutions around the world (ADAC, TÜV, Mercedes-Benz, Škoda Auto, Czech Technical University in Prague – Faculty of Transportation, Charles University - Faculty of Physical Education and Sport, etc.). It is a complex problem of a mechanically complicated system of viscoelastic elements (segments of the body, tissues, organs, etc.) interconnected by joints with variable stiffness and controlled by the nervous system. Therefore, relevant results can be achieved only by studying the problem through intermediary steps, both with experimental and simulation methods using validated objects and a mutual comparison of its results.

A serious bicycle accident can affect anyone who rides a bike both on the street and in the countryside, either quickly or slowly. We can presume that there is no threat if we are riding a bicycle in a quiet neighborhood, but according to iBESIP (2008) most of the serious accidents in which cyclists were involved in happened close to home, and also the majority of fatal accidents have taken place in residential areas.

The cyclist's head is affected in half of all cyclist accidents – it either hits the car or the ground. The most common site of injury for children, occurring after the fall of the bike, are: head – 44%, arms – 27%, stomach – 6 % and knees 23% (iBESIP, 2008).

There were 77 cyclists killed on the Czech roads, including 2 children under the age of 14 years. Another 431 cyclists were seriously injured and 2516 slightly injured. These figures are but the tip of the iceberg, since it is only for those cases where an accident was reported to the Police and then appeared in the relevant statistics. The seriousness of accidents (deaths per 1 000 accidents) caused by cyclists in 2008 was 19.6, the second highest after motorcycle riders. Out of the total number of 77 cyclists killed in an accident, 68 cyclists wore a helmet, i.e., 88.3%. In the case of severe injuries 348 cyclists were not wearing a helmet (80.7%) and in case of slight injuries 2041 cyclist were not wearing a helmet (81.1%).

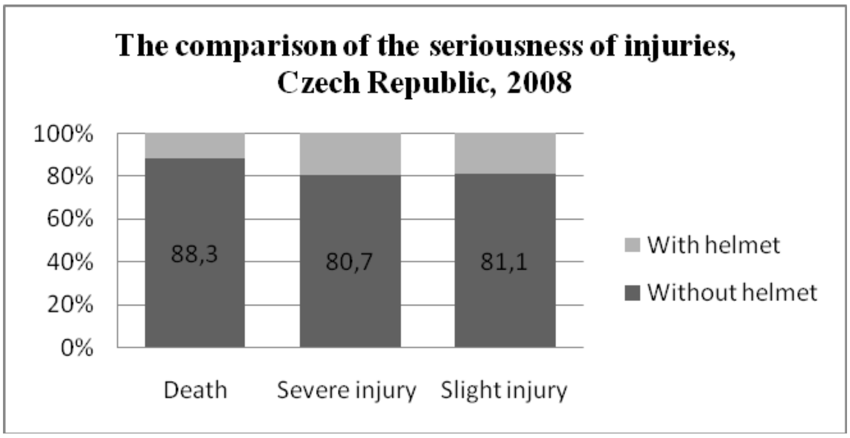

Figure 1 – The seriousness of injuries of cyclists with helmets and without helmet.

The side-impact (Figure 2) is the most common type of bicycle/car collision according to a study (Table 1) from the U.S. for the period 01/01/2007 to 06/30/2009 (Bike Accident Summary, 2010).

Side-impact (Broadside)	214
Overtaking Turn	46
Leftward Turn (Approach Turn)	33
Contra-flow-lane ride (Sideswipe)	30
Impact with parked car	8
Rear-impact	8
Rearward ride	5

Table 1: Summary of types of collisions.

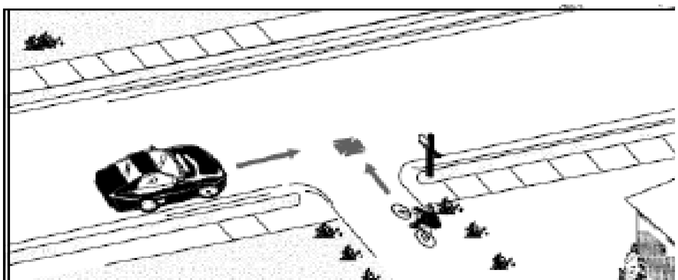

Figure 2: Side-impact (Bike Accident Summary, 2010).

2 PEDESTRIAN THROW RELATIONS

The usual question during the reconstruction of pedestrian accidents is how fast the car was driving when it hit the pedestrian. Groups of investigators determine the relations specially appointed to estimate the impact velocity of the vehicles. It is based on the throw distance measured directly on the spot. Such questions also arise with the accidents of cyclists.

Can some of the patterns also be use when cyclists are concerned? Previously published formulas for calculating the throw distance of pedestrians will be considered to be relevant and will not be studied more deeply.

Schmidt, et al. (1971) assumed that the impact velocity is related to the distance between the contact point and the final point of rest of the pedestrians on the ground. By including the height of pedestrian's center of mass they set the relation:

$$Vimp = \sqrt{\mu^2 \times h + 2 \times \mu \times g \times Dt - \mu \times h}$$

Where:
Vimp = impact velocity of the car (km/h)
μ = coefficient of friction
h = height of pedestrian's center of mass (m)
Dt = throw distance (m)
g = acceleration due to gravity (m/s^2)

Collins, et al. (1979) also used the height of pedestrian's center of mass and adjusted their equations into the quadratic formula to get the impact velocity:

$$a = \frac{1}{254}\mu \ , \ b = \frac{\sqrt{h}}{7{,}97} \ , \ c = -Dt$$

$$Vimp = \frac{\left[-b + \sqrt{b^2 - 4ac}\right]}{2a}$$

Searle, et al. (1983) developed two equations that provide upper and lower estimates of speed and recognize the unique problem of collision, which is that the fall is accompanied by rolls and flight phases of the pedestrian.

$$Vimp_{\text{min.}} = \sqrt{\frac{2\mu \cdot g \cdot Dt}{1 + \mu^2}} \cdot 1{,}097$$

$$Vimp_{\text{max.}} = \sqrt{(2\mu \cdot g \cdot Dt)} \cdot 1{,}097$$

Wood (1997) distinguishes whether the body was shifted across the hood (center of mass is above the leading edge of the car) or whether it was projected forward (center of mass is below the leading edge of the car), equations provide upper and lower estimates of impact velocity:

$$Vimp = K \times \sqrt{Dt}$$

Where:

$K_{wrap\ MIN} = 3{,}3$; $K_{forward\ projection\ MAX} = 4{,}7$

$K_{wrap\ MIN} = 3{,}01$; $K_{forward\ projection\ MAX} = 4{,}72$

Limpert (1999) estimates the accuracy of his equation within plus or minus 4 km/h. As opposed to the other relationships the coefficient of friction in Limpert equation is related to the tire and the road:

$$Vimp = 6{,}6 \cdot \sqrt{8{,}4\mu_p{}^4 + \mu_p \cdot Dt} - 20\mu_p{}^2$$

Where:

μ_p = coefficient of friction – vehicle tire to roadway

Fugger et al. (2000) developed a simple non-linear equation to calculate the impact velocity. It is applicable for car to pedestrian impact on regular asphalt roadways.

$$Vimp = 8{,}3604 \times Dt^{0{,}6046}$$

3 MADYMO SIMULATION

A model of a pedestrian was selected from a database of Madymo software for this simulation. It is a model of the human body 50% of standing pedestrians “h_ped50el”. All the features of the model are adopted. The model of pedestrian was seated with the help of the JOINT parameters corresponding with modeled mountain bikes, road bikes and touring bikes (Figure 2). The deformation characteristic of the bike contact consists of the FORCE system with defined features. Contact between the wheel and the ground was taken from the Madymo database. The contact between a bike and vehicle components, and a bike and a model of a pedestrian, has also been defined. The FRIC.COEF has been used to set the friction between the bike and the pedestrian, especially saddle and handlebars. Gravity influences the whole system.

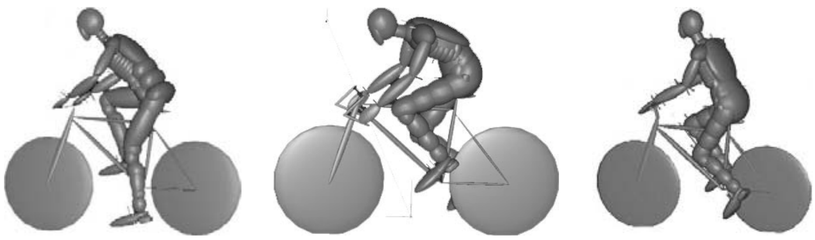

Figure 2 – Mountain, Road and Touring Bike.

A simplified vehicle model consists of planes, cylinders and ellipsoids where contact stiffness is defined. Reference values of stiffness (deformation characteristics) are used due to the difficult accessibility of these values. Three types of cars were modeled - SEDAN, SUV and MPV with the characteristics of the vehicle fronts (Table 3) that represent the types of such cars in these classes (Figure 3).

Table 2: Parameters of cars.

	SEDAN	SUV	MPV
Height of impact edge (m)	0,42	0,66	0,50
Height of leading edge of hood (m)	0,63	0,90	0,70
Height of the end of hood (m)	0,83	1,12	1,00
Length of hood (m)	0,70	0,77	0,60
Angle of hood (degrees)	16,6	16,6	30,0
Length of windshield (m)	0,96	0,96	1,10
Height of upper edge of windshield (m)	1,36	1,65	1,60

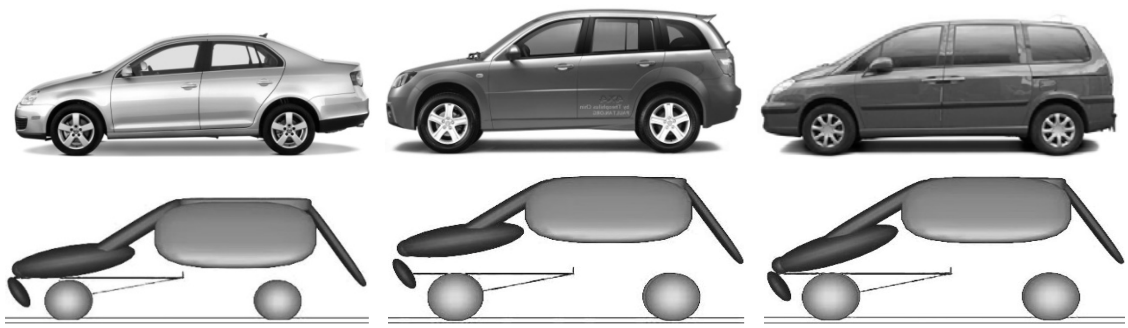

Figure 3: Types of cars (SEDAN, SUV, MPV).

The roadway is represented by a horizontal surface with high stiffness. The characteristics of the roadway and the contact as a factor of friction and the attenuation coefficient are also adopted.

There were 48 simulations made of the most common type of collision - the side-impact (Broadside). According to ISO 13232 for motorcycles it is a configuration of objects 143. The cyclist was moving at 15 km/h upright to the direction of driving car. The car crashed into the left side of the cyclist. The initial vehicle speed was 35 km/h, 40km/h and 65 km/h., and the deceleration was 8.0 m.s^{-2} in all cases. It corresponds to intense or panic braking. The primary and the secondary contact with the car body were studied in particular and then the trajectory of the cyclist's movements both in the air and on the land, including tertiary contact.

4 FLIGHT OF A CYCLIST AND THE FALL ONTO THE GROUND

The movement of cyclists in the air (flight) is mostly influenced by the car's speed at the moment of impact. According to the trajectory of a cyclist, the speed can be described as low or high. With low speed the cyclist does not fly over the roof of the car, whereas with high speed the cyclist flies over the roof of the car. In our simulations at 35 and 40 km/h there was no flight over the roof. At a speed of 65 km/h flight occurred with the SEDAN and MPV.

The cyclist was thrown diagonally forward with rotation in the driving direction of the car by the SEDAN. The SUV-type of car with a broad vehicle front and high impact edge ladled the cyclist with the front and swiped them slightly sidelong forward. The body found itself all the time in a lower position than with the SEDAN. The cyclist was swiped sidelong forward by MPV, as well as by the SEDAN. However, the movement resultant was steeper and the flight height was higher, because of shorter and more sloping vehicle front.

The trajectory of movement at the speed of 65 km/h is characterized by the flight over the roof by the SEDAN (Figure 4) and by the MPV (Figure 6). A stronger swipe forward in front of the vehicle was observed by the SUV (Figure 5).

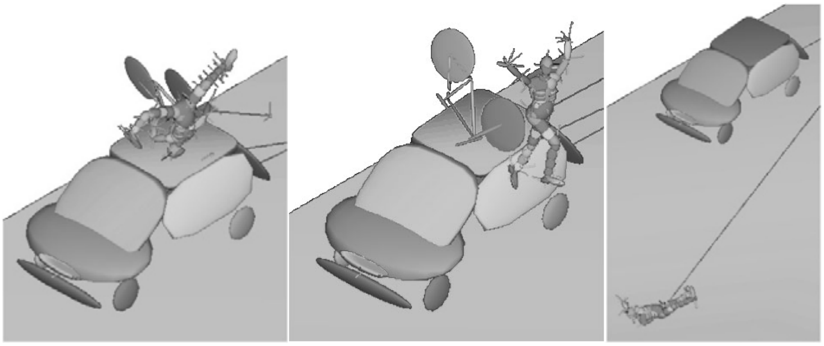

Figure 4 – Strike of the cyclist – SEDAN - 65 km/h.

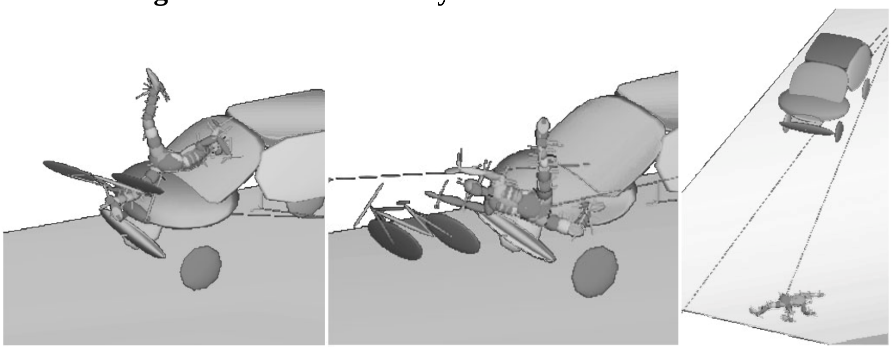

Figure 5 – Strike of the cyclist – SUV – 65 km/h.

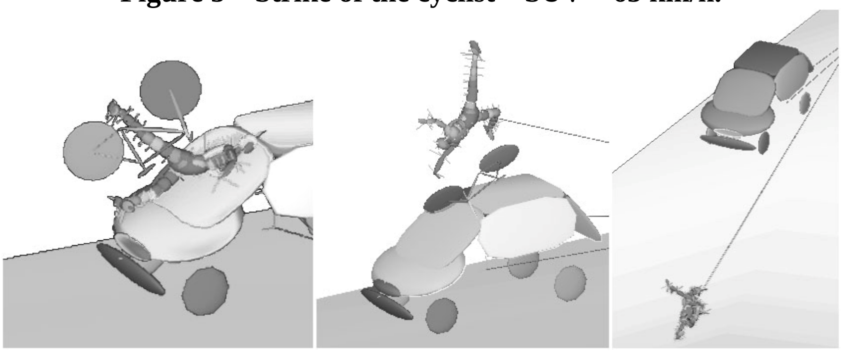

Figure 6 – Strike of the cyclist – MPV – 65 km/h.

5 SUMMARY

Comparing the results from our Madymo simulation and the real Crash Tests carried out by Broker et al. (2006), we can conclude that the simulations show consistent patterns in: the shape of the front of the car (height of impact edge), the speed just before the impact, height of cyclist center of mass and the throw direction. Either flight over the hood or only the ladling of the cyclist and their swipe forward can be observed in a dependence on the speed. If the impact edge of the car is below the cyclist's center of mass the body is rotated and swiped up sidelong forward. If the impact is in the center of mass the cyclist is ladled up by the car and then swiped forward in front of the car.

Both the movement of the bike and the spot of the fall on the ground were consistent with the results of the crash tests carried out by (Broker, et al., 2006). The throw distance of the bike was larger than the throw distance of the cyclist, the linear regression is $y=2.94x-25.5$ (for the bike) and $y=2.36x-14.8$ (for the cyclist) out of 105 crash tests. The throw distance of the bike was always longer than the throw distance of the cyclist in our simulations.

Figure 7 – Demonstration of the crash tests carried by Broker, et al (2006).

To analyze the cyclist accident using the relations relevant for pedestrian throw, the car speed just before the impact was 40 km/h. The throw distance for each type of car and the position of the cyclist are in Table 4. The speed determined by using the Schmidt et al. (1971) relation differs on average by 3.3 km/h and approaches the best of all non-interval methods the speed of 40km/h, while the smallest deviations are observed by the SUV and the MPV. The speed according to Collins, et al. (2000) differs on average by 6.3 km/h, according to Limpert (1999) by 8 km/h and according to Fugger, et al. (2000) by 10.5 km/h. If the interval method (Wood, 1997) was used then the calculated speed was correspondent with the SUV and the MPV. The values calculated according to Searle, et al. (1983) were slightly below the real speed, mainly with the SUV and the MPV.

The used relations were initially meant to analyze the pedestrian impact. We must take into account that the initial speed of a cyclist is higher – in our case 15 km/h., with pedestrians the maximum is 5 km/h. The total speed of the impact is higher with cyclist and consequently also the flight is longer. Another difference is the height of center of mass of the cyclist compared to that of the pedestrian. The cyclist's center of mass is higher and also the height of flight of the cyclist is higher, and consequently also the throw distance is longer.

Table 3 – Calculation of the car's speed just before the collision.

Type of car	Type of bike (position of cyclist)	Throw distance (m)	Schmidt, et al. (1971) (impact speed / deviation)		Collins, et al. (1979) (impact speed / deviation)		Limpert (1999) (impact speed / deviation)		Fugger, et al. (2000) (impact speed / deviation)		Searle, et al. (1983) - min max (km/h)		Wood (1997) - min max (km/h)	
SEDAN	Mountain	6,91	34	15%	30	25%	29	28%	27	33%	28	34	25	36
	Road	6,45	33	18%	29	28%	27	32%	26	35%	27	33	24	35
	Touring	7,25	35	13%	31	22%	30	26%	28	31%	29	35	26	37
SUV	Mountain	9,79	40	0%	39	3%	37	8%	33	17%	34	41	27	43
	Road	8,41	38	6%	35	13%	33	17%	30	24%	31	38	25	40
	Touring	8,45	38	6%	35	13%	33	17%	30	24%	31	38	25	40
MPV	Mountain	8,84	38	4%	36	10%	34	14%	31	22%	32	39	29	41
	Road	7,92	36	9%	33	17%	32	21%	29	27%	30	36	27	40
	Touring	8,51	38	6%	35	12%	33	17%	31	24%	32	38	28	40

6 CONCLUSION

If we compare the issue of the impact with a cyclist and the impact with a pedestrian we can conclude the mechanisms are alike. The speed before impact is supposed to be higher with the cyclist which is why the impact seems to be more serious. The higher speed with the side impact can cause the cyclist to fall on to the front hood sidelong. A positive consequence of the speed of cyclist with the side impact is that the cyclist slides on the front splashboard. Another difference is in the position of center of mass – that of the cyclist's is higher, and in the mutual position of center of mass of cyclist and the impact edge of a car.

Regarding the possibility of using the relations designed to estimate the impact speed based on pedestrian throw distance, we can use the formulas for cyclist side impact accidents only to a limited extent. The most suitable is the Schmidt et al. (1971) formula and the interval method of calculation by Wood (1997) but only for SUVs and MPVs.

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Decarbonisation of Transport and Modal Split

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ABSTRACT: A predominant section of world experts, policy-makers and the general public are concerned with the danger of climate change caused by great volumes of emissions which are potentially growing. These emissions are connected with the predicted growth of sectors of the economy with a high level of emissions (namely carbon dioxide). The European Union has organised a huge effort in science, research and development to decrease emissions based on the last frame programmes of R&D&I; joint technological initiatives with relevant sectors of the industry; legal groundwork, especially in road transport; incentives to markedly diminish the present 22% share of road transport in total emissions. It is clear that, despite some uncertainties due to the results of parallel research, and despite the development in progress not being known, e.g., what type of propulsion, based in principal on electric current from nuclear power stations being better (whether only network and batteries, or in addition hydrogen and fuel cells) should have the greatest energy or cost efficiency; the parallel effort assures incomparable benefits for future development. A great majority of the results of these activities should be usable even in other modes of transport, especially railways. The general description of expected results in the development of technologies have proved great expectations in changes in modal split in comparison with the recent position, with necessary changes in all future decades.

KEY WORDS: modal split, decarbonisation of transport.

1 INTRODUCTION

A significant section of global experts, policy-makers and the general public has been aware of the danger of climate change due to the great and continual growth of volumes of emissions of greenhouse gases, and has promoted an as large as possible reduction of the emissions (namely carbon dioxide). Such a target for the EU is very ambitious. Future development is contrary to the huge development of production, even in the sectors of the economy with the highest recent shares of emissions, which should be decreased during the next decades of the first half of this century to a level of the last decades of the last century.

Recently, the sector with one of the greatest shares of emissions is road transport, with nearly a 22% share of total emissions. (Mentioned in all the main documents of the European Commission prepared both as a contribution of the EU for Copenhagen UN summit at the end of 2009, and discussions for the prepared White Paper on the European

Transport policy 2020, and relevant parts of the documentation towards the programme Strategy Europe 2020 without any dispute).

Other deficiencies yet disputed are the non-renewability of sources of fossil fuels and the great share of these resources in politically or environmentally risky areas outside of Europe, and how to replace these with alternative sources whilst not reducing the efficiency to a significant extent. These are a series of topics solved within the 6th and 7th Frame programme of research and development.

Due to these main reasons there is an enormous effort by the European Union to reach the decreased level of emissions of greenhouse gases.

The basic tool is the immense activity in the area of science, research and development, massively supported through funding from the budget of the EU, with joint technological initiatives of the relevant production sectors of the industries, to combine this public funding with the private funding of the automotive industries and their suppliers, etc., with the maximum supporting legal and administrative measures and additional incentives for the private sector.

All these accepted proposals were based on a new generation of scientific and research projects. Therefore, in the References section we shall quote as literature only the basic documents of the European Commission as a superstructure providing innovations, instead of the many research papers and studies.

2 SUBSECTOR ATTITUDE IN TRANSPORT

It looks like the main attitude in the technological development of the European railways is the ERTMS system of control of railway traffic and proposals for investments to improve the quality of transport services. The competitive position of railways should by based on the lower emission of carbon dioxide and noise, but, because of similar future sources of energy and propulsion, these competitive advantages will be equalised. The idea is often expressed that local and regional railways, especially, will still have lasting subsidies in the year 2050, while the freight traffic could be without any subsidies by this time, because of the belief in more expensive fossil or alternative fuels and noise emissions. Due to renewed competiveness, the European railways should have, in the case of the transport market of goods, a dominant share of work for distances over 300 km and high-speed trains. There are no issues with propulsions, because of the high level of electric traction. However electrification of all modes of ground transport is supposed, and electrified local and regional lines should be additionally profitable to the railways magistral lines without trolley lines, based on the research intended now for road vehicles, if the density of traffic should not be too high to pay the expensive trolley line supply system.

Another repeated idea is to let road transport pay uncovered externalities. However, especially on regional and local rail lines, the main issue of comparability of externalities is in the density of the traffic: such a high number of transport railway units necessary to cover the cofounding (with public funds) costs of infrastructure, could only be reached on some parts of the network of local and regional railway lines in rural regions. On the other hand, the high density of road transport always needs only a fraction of the total cost of the road infrastructure per vehicle unit.

3 OTHER FACTORS

The development of the electrification of the transport system is only seldom connected with the anticipated nuclear fusion, instead of nuclear fissure, either through the business implementation of results of ITER (International Thermonuclear Experimental Reactor), or high–capacity lasers. The other priority of the implemented ITER is only a very small amount of nuclear waste; it is supposed that for a nuclear reaction and the production of electricity equivalent to 7 million coal equivalent there need be only 3.5 kilograms of plutonium, whereas the reaction should be in case of necessity stopped immediately.

In connection with such an energetic hope of mankind it is worth mentioning the tremendous change in the attitude to the discoveries in the nuclear sector: instead of competition combined with the highest degree of concealment, due to the primary military purpose of previous nuclear projects, there has been very close cooperation between the five competing industrial superpowers and the European Union, even though, only some decades ago, they were in the position of being the greatest military rivals. There was for a relatively long period hold-ups due to the competitive position of the site of the experimental facilities (either in Japan, or France- Cadarache, near Marseille, the effort of one half of the present participants of the ITER- Japan- after their bad 2nd world war experience with nuclear power; after European localisation, the locality was compensated by the position of Japan as a general director of the ITER, etc.). Other compensation has been in the sharing the additional joint world nuclear experimental facilities, supplementing, in some way, the main facilities. Successfully negotiated agreements caused great time delays in the starting stage of the project ITER.

4 NEW PROPULSIONS AND TECHNOLOGIES INITIALLY SUPPOSED FOR ROAD VEHICLES

The implementation of the ITER in the energy business would open the way to the massive electrification of road transport without some great present environmental constraints. Parallel to a relatively small part of conventional fuel with a very low prescribed level of emissions of carbon (through carbon dioxide), are alternative fuels for combustion engines, in next decades electrical propulsion using new batteries with accumulators with a higher capacity to bridge the distance between two power supply units or after daily operation to load the battery after some hundreds of kilometers of distance moved.

And despite disputes connected to issues with the storage and distribution of hydrogen, there is great hope for commercial hydrogen driven road vehicles, or of hybrid vehicles with basic drive using hydrogen and forced supplementary drive using the batteries of accumulators, with the recuperation of energy from breaking.

Hydrogen production demands cheap electrical energy. Nuclear fusion could give it.

Naturally, there are some above-mentioned issues concerning the storage and distribution of hydrogen for filling stations, due to the necessary safety measures for handling; much more risky than in the case of oil. But concerning research programmes this should be solved within the issues connected with the future energy policy.

All proposed changes should mean that if the recent number of motor vehicles is about 800 million, the predicated number of motor vehicles in 2030 could be 1600 million motor vehicles, and in 2050 about 2500 million; the recent level of emissions should drop by 2050 by 80 % to 95 %. (About three documents – MEMO, Communication and supplementary information from 28th April 2020). This means that the present levels of emissions per car would drop on average to the level of only some % - mostly due to electrification. In the case of electromobils with the exception of abrasion of braking equipment and tyres, and the abrasion of carriageways, nearly all segments of emissions should mostly be reduced or disappear.

The most problematic issue with the rather limited possibility of improvements shall be in the case of the quality of the roads, because of money saved for decades necessary for the maintenance of and investments in the transport infrastructure and measures against floods.

There is another harmful effect: due to the periodic review of the Eurobarometer concerning road safety there are two main sources of road accidents, namely fatal accidents: the first is connected to the lack of discipline of drivers (hand-manipulated mobile phones included), the second due to the insufficient capacity and worse quality of road transport infrastructure.

5 COST EFFICIENCY

The new technologies of propulsions, namely electrification, are now about two to three times more costly than conventional propulsions. It is partially due to low-level (batch) production. Some issues could be solved using the legal practices of EU regulation –binding instructions to preferential buy the most energy- and emissions-efficient vehicles. As to the majority of cars used for commuting, especially in cities and towns (with more cars in household), the total costs could be even now reduced using smaller cars in comparison with present middle-sized vehicles.

There is huge support of the scientific activities, research and development of new types of batteries- with higher capacity and cheaper.

The decrease in the prices of electrical current for classical electric traction with trolley lines should be very significant, at least in comparison with fossil sources.

But there will be cheaper electrical current for the electrolysis of water to produce hydrogen for fuel cells, if they would be used.

Solving issues with the transportation of tanks with cheap liquid hydrogen could bring large impetus to the use of fuel cells, with rather simple equipment: two carbon electrodes with a small amount of catalyst, divided by a thin polymeric membrane that allows the protons to pass through. The hydrogen is then dissociated into protons and electrons on the catalyst layer. The protons pass through an external electric circle and essentially power the electric engine. Two protons are combined with two electrons and an atom of hydrogen from the air formed vapour of water and than hot water.

The prices of electrodes are rather high, as well as the polymeric membranes, but they have dropped even now very significantly on account of the research and development that has contributed to the considerable prolongation of service life.

The third element to the height of the price level and environmental friendliness is the above mentioned recuperation of 60% of energy during breaking.

There are some heavy disputes to the extent of the possible use of fuel cells in comparison with a “pure” electric car. The rather optimistic view could be caused by the practical application of this technology in buses. It could bring cheaper railway operation on account of unnecessary trolley lines.

But much lighter electric cars for cities are to be expected in comparison with present day vehicles of universal utilization, both for use in cities and for travelling long distances.

The total revolution in transport technologies could be illustrated by the fact that, just at present, there are emissions of noise and the noisy road transport are understood as an environmental constraint in comparison with railways (mostly because of housing closer to the road compared to railway infrastructure). But such hope will be false: the low level of noise emission of electric vehicles needs to produce an agreeable noise to warn other participants of road transport that an electric driven vehicle is coming.

During some future decades it is possible to suppose that due to the decreased prices of road vehicles and their operation, and because of the higher standards of living, everyone with prescribed age and healthy conditions could have and drive motor vehicles, and may be prolonged by means of ICT, if he would decide to have it.

On one hand there is a good perspective of the possibility to reach rather comparative prices of new transport technology with the conventional. On the other hand, as it was mentioned, the new types of propulsions based on electricity have not been developed only for road transport.

6 THE MAIN FUTURE CONSTRAINTS

In case of road transport there should be only two groups of constraints in the future:

- The capacity of transport infrastructure for traffic operation on roads and in streets for through traffic, because issues of created obstacles by parked cars for through traffic not only make smooth traffic flow difficult, but block emergency traffic too. The issue shall be, in comparison with today, much more difficult, not only because of the growth in the number of cars, but also the traffic of goods, choosing road transport: in the period 2000- June 2008 July 2008 (which has been announced as the starting point of the financial/economic crisis) the rates of growth of employment of small and medium size enterprises (SMEPs) were, in the European Union, 1.9 % per year on average, in comparison with large enterprises with only 0.5%. It is supposed that after the crisis this relation in the growth of enterprises should continue, if it shall happen to implement all 10 groups of issues supposed by the Act of small enterprises. But despite this precondition only 20% of SMEPs are involved in cross- board operations. Their share of turnover on cross-border operations has been only 8%. It means that the predominant markets are on local and regional levels, with the requirements of a lesser amount but higher frequency of orders. The requirements will therefore incline to traffic on a local and regional level, and this means to road transport.
- A part of these expected future bottlenecks could be reduced, especially in daily commuter traffic.
- But in general all cuts in road investments cannot be caught up, with tremendous effects on the smoothness of traffic and, in parallel, on a higher rate of accidents, including fatal incidences.
- The second case of issues is to build enough capacity for parking and put aside vehicles, not used for daily traffic, but for example only during weekends.
- There is no alternative, especially not for parking in streets, because they will block through traffic.

7 INTEGRATED TRANSPORT SYSTEMS

As to the above-mentioned remarks, the only possibility is to decrease daily traffic and in such a way to slightly diminish great future bottlenecks.
To find the best modal split under the future conditions it is necessary

- to revaluate the old-fashioned hypothesis that a vehicle with higher capacity is ceteris paribus more efficient, despite the level of insufficiently used occupation, because the excessive offered capacity would be used later on.

- then, based on the environmental parameters of new vehicles (mainly the substantial amount of emissions of carbon dioxide), to derive a lower and upper limit of occupation of vehicles in order to find the optimal solution of the relation capacity- consumption of fuel- emission- acceptable costs.
- it is necessary to clarify the prolonged travel time (travel distance) for combined transport (journeys with a necessary change of means of transport), that in any way should lengthen the travel time without change.
- sub-alternative is the change of vehicles in points (junctions) with consolidation of flow of passengers of vehicles with low capacity and consumption, with a change for vehicles with higher capacity and its adequate use and therefore lower specific consumption.
- if possible to compensate time delays by higher comfort of travelling and/or prices of tickets.
- could be possible to connect breaks in travel time by changing the vehicles providing supplementary services for passengers?
  - permanently or
  - only during some journeys depending on daily hours, days in week?
- because the decisive element should be the choice of the passengers.
- integrated transport systems due to more participating operators need excellent control and information systems of participating vehicles, drivers, passengers, not only for smooth normal traffic operations, but especially in the case of any interruption of transport operations of any participant of the system, with the necessary costs that could be compared not only with lower consumption, lower amount of emissions, but also cost efficiency.

8 CONCLUSIONS

In principle it is necessary to say that the future optimal modal split could neither be based on the previous paradigms nor on paradigms valid for the whole period from recent to future time horizons 2020, 2030, 2050. The pace of the development of society and technology is too quick.

Technological development could further satisfy the needs of mobility using cars with an acceptable environmental impact, or transport means of collective transport within the framework of integrated passenger transport systems, influenced partially in the case of short distance travelling by the excellence of the organisation of transport with only very short and acceptable interruptions of journeys connected with changing the means of transport. Integrated transport systems could spare segments of the capacity of the infrastructure with a greater occupancy of vehicles of collective transport, if it should happen to necessarily reach at least lower occupation, with prices and comfort comparable with cars.

The only threat to the smooth flow of traffic and the rate of accidents inclusive with fatal consequences will be the insufficient level of quantity and quality of road transport infrastructure in general, even in the case of roads and streets of lower classes.

The development of high-tech in the case of vehicles of all modes of transport and the growing level of safety measures should not be a great contradiction to the level of infrastructure, even after reaching the level of minimal harmful environmental impact, otherwise there should be great problems and even danger to life.

But the many decades of time delays in financing transport infrastructure, combined with the relatively high degree of road accident frequencies fatal accidents included in connection with some delays caused by present financial / economic crisis could sharpen such imbalances.

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Proposal for a Wheel Suspension Mechanism with Controlled Characteristics

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ABSTRACT: This article presents the design of an overconstrained suspension mechanism based on five-link suspension. The system contains kinematic joints with a simple on-off control system, which enables it to change the kinematic scheme and, consequently, the suspension characteristics (the longitudinal and lateral movement of the wheel centre point, steering angle, camber and caster angle, etc.). A wheel suspension mechanism with controlled characteristics enables the adaption of suspension behavior according to the driving situation and an optimization of the vehicle dynamics, handling and comfort.

KEY WORDS: vehicle suspension, suspension characteristics, redundant wheel suspension, five-link suspension, adaptive suspension kinematics

1 INTRODUCTON

Wheel suspension and control mechanism is a constrained mechanical system allowing the connection of a sprung mass (car body) and spring unsprung mass (wheel, wheel support, accessories) in such a way as to provide the best possible conditions for tyre-road contact and driving comfort. The position of the wheel on the road and the position of the key geometric elements during vertical movement (springing to car body) is described by charts known as suspension characteristics. Their forms are based on the required tyre-to-road position persistence (this condition is derived from the design of the tyre used) drive comfort affected by the transmission of vibration, forces transmission onto car body during braking, acceleration, and direction change. These characteristics can often be a compromised solution attained from the various requirements of driving safety and comfort conditions. The requirement of a forward incline during braking is, for example, contradictory with the vibration transmission when driving along uneven roads. Moreover, the definition of these characteristics are formed based on the predictable states of the vehicle and are not adaptive according to changes in conditions or the requirements of the current driving conditions of the vehicle.

2 SOLUTION

The presented solution is based on the presumption of mechatronic features existing in the vehicle, i.e., the action elements that set the requested state of the mechanism and sensors for the driving requirements detection. The wheel suspension mechanism is, in this case, constructed overconstrained (members and kinematic pairs) than needed to reach one degree of freedom for vertical movement (caused by springing), and some kinematic pairs must, therefore, be actively controlled. Without this, the system would be kinematically overstated and would have zero degrees of freedom and redundant constraint equations in case of blocking more of the controlled kinematic pairs than requested to reach the needed mobility. On the other hand, more free pairs would lead to unwanted mobility. Therefore, the system is equipped with pairs that can be blocked or activated by the control system of the mechanism in order to reach under this setting the requested one degree of freedom. The chosen kinematic pairs can be blocked or activated by the control system in such a way that the suspension has the required characteristics, or the rigidity of the springing-suspension members in the kinematic pairs and the elasto-kinematics of the suspension is affected, or it can fluctuate between two extreme characteristics of suspension.

This kinematics construction, equipped with the control of the mechanism, makes the suspension designing process more complicated, and it brings with it active members and potentially increases unsprung masses. However, it even brings the possibility to optimally choose the suspension characteristics improving the tyre-road contact, horizontal, vertical, and lateral dynamics of the vehicle and affects the noise and vibrations in the vehicle. By this means, it even improves the safety and driving comfort.

It is necessary to say the kinematically pre-set systems are used in cars already. As examples, we can state the chasis with compound crank axle and exquisite elastokinematic characteristics.

3 EXAMPLE OF SOLUTION

This system can be described by a suspension system with five elements (Figure 1), without the steering mechanism (rear axle). There is one element added in the suspension – it is the binary member with two spherical pairs. The mechanism would become a rigid (zero degrees of freedom) construction and therefore we locate two selected spherical pairs on the chassis of the vehicle in such a way that their sliding movement is allowed and by active power members we will control their movement (released-blocked status). The result will get the different kinematic schemes for different settings that end up in different suspension characteristics. In the example mentioned above (transmission of vibration and forward inclination during braking), the longitudinal wheel movement characteristics is principal (Figure 3). This longitudinal movement of the wheel centre can either support the contra-forward inclining movement during braking (the wheel travels forward and upward when braking) or we can limit the transmission of vibration when braking on uneven surface (the wheel travels backward and the stroke power is limited when getting on the terrain obstacle). The solution made by blocking and releasing the respective pair (Figure 2 and 3) can affect the behaviour described in accordance with other input data, which comes to the control systems, and we can choose the optimal settings for the respective setting (speed, intensity of braking, road surface quality). There are various situations applicable on lateral and sideway dynamics (e.g., the affection of mutual co-action and relation of wheel on the same axis when driving through the curve under different conditions, etc.). The properties of many suspension types can be derived from their kinematic schemes of five-element suspension, the given solution can be taken as general, and the principle can be used for all suspension types and steering settings in road vehicles of all categories, air vehicle carriages, etc.

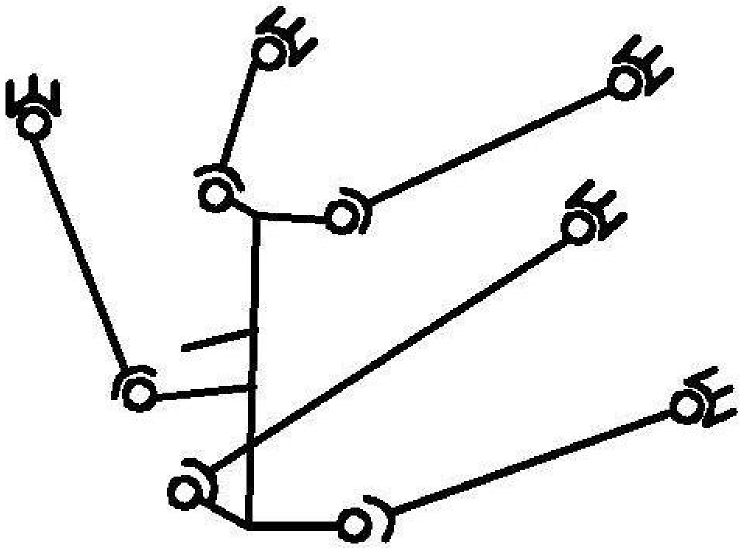
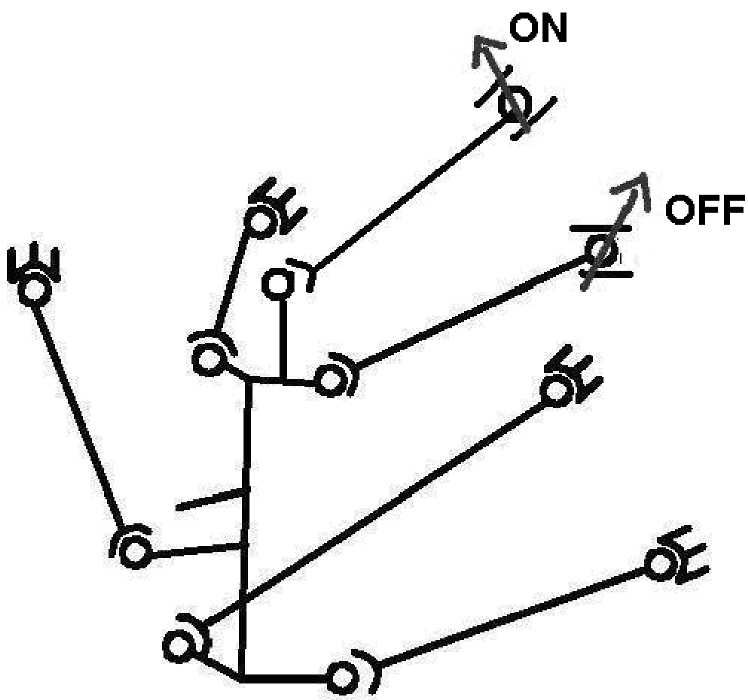


Figure 1: Original scheme of five-element suspension with fixed kinematic scheme.



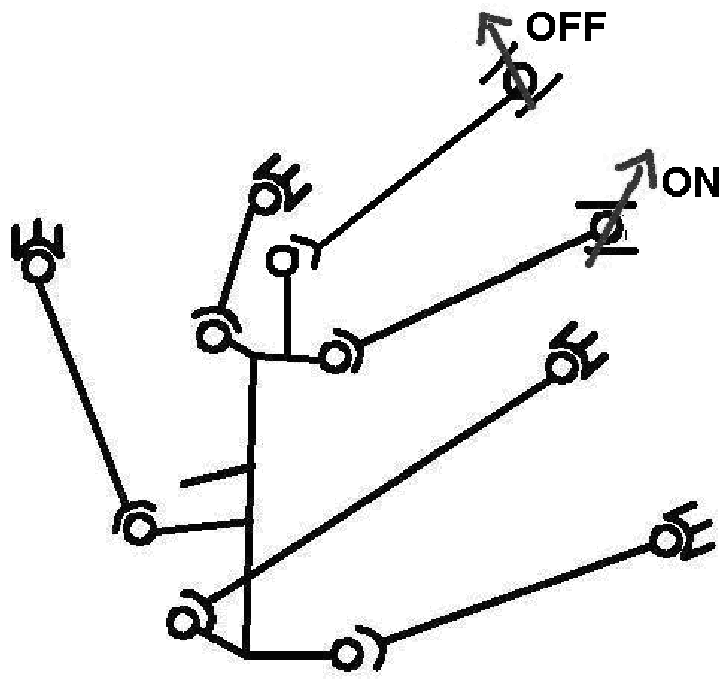


Figure 2: Modified suspension with additional kinematic constraint and sliding linkage of spherical joints with shift management (indicated by arrows, OFF is unlocked and sliding).

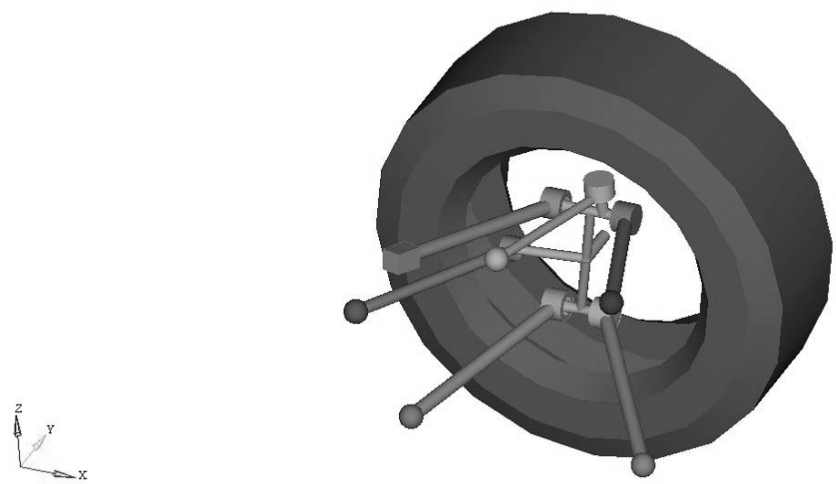


Figure 3: CAD model of suspension (rectangular joint is sliding).

The example of suspension with two controlled shifting connections is described in Figure 2 and Figure 3, in this case one connection (arrow) is “on” and the other “off”.

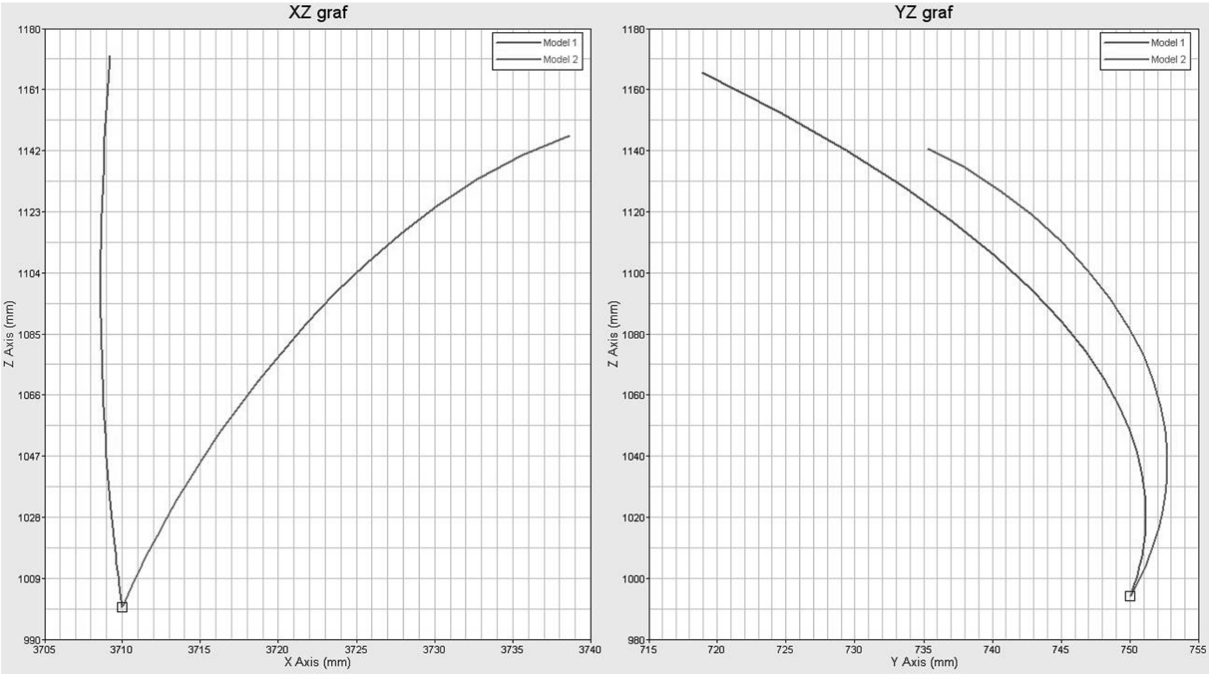


Figure 4: Longitudinal (left) and lateral movement (right graph) of wheel centre point during suspension for two different settings. Suspension movement (in positive z direction) is on vertical axis, movement starts at a selected low suspension position.

Other characteristics that can be affected in the same way are, for example, the change of wheel camber angle, change of self-steering angle during springing, and the subsequent improvement of wheel-road contact in different situations. The effect of suspension characteristics change can be efficiently used in synergy with the control of systems such as ABS and ESP, eventually ABC, in connection with which it can make up a complex system. The system described has the minimum requirement on the active members and, through that, the energy needed for the control.

4 CONCLUSION

The above proposed change of the mechanism can be realized through various design changes, e.g., by the introduction of controlled spring-suspending members in spherical pair joints in the car body. The switching system for these slides can than allow change in kinematic characteristics in such a way as to be advantageous for the respective driving conditions and state. The system described above is a direct contribution to the active safety of driving by means of tyre-road contact and transmission of vibrations from the chassis onto the car body. Even if the proposed solution seems to be promising, further investigations are needed in order to evaluate the engineering feasibility and the reliability of such a suspension system.

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Traffic Conflict Techniques in the Czech Republic

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ABSTRACT: This article deals mainly with defining a way of monitoring traffic conflicts. This issue is only one part of a greater safety analysis, or risk determination process for a particular location. Based on the described procedures it is possible to apply the methodology also to more complicated nodes, such as level crossings, sections of towns, residential areas, or rural areas. After the survey and the collection of a necessary amount of transport and engineering data, the determination of a relative number for the "almost-accident rate" (number of calculated vehicles for a selected time period and the number of traffic conflicts – so-called almost-accidents) may be calculated.

KEY WORDS: Traffic conflict techniques, monitoring traffic conflicts, safety analysis, accident

1 INTRODUCTION

In most road safety studies, analysts use the information contained in accident reports to identify and understand the failures of the road system and then propose appropriate corrective action. While these analyses are essential, it is well recognized that accident data suffer from a number of shortcomings and need to be complemented by field observations in order to improve the accuracy of safety diagnoses. The traffic conflict technique (TCT) was originally developed by researchers from General Motors Laboratories who wanted to investigate whether GM cars were driven differently than others (Perkins and Harris, 1968). Since then, several variants of the original TCT have been proposed. Almost all traffic conflict techniques take into consideration the need, for at least one road user, to take evasive action in order to avoid a collision (braking, swerving, accelerating, or a combination of these manoeuvres). A well-accepted definition of traffic conflict is:
"an observable situation in which two or more road users approach each other in space and time to such an extent that there is a risk of collision if their movements remain unchanged".

2 METHODS

My research is focused on traffic conflicts as an alternative to accident data. Conflicts occur far more frequently in traffic and can include the whole range of incidences where the actual accident is just at one end of the scale. Techniques range from subjective to the more objective where conflicts are rated by measurements such as time to collision or post encroachment time. Two accident locations are analyzed in my dissertation work. This research advances the research of Dr. Folprecht (Ostrava).

I applied the traffic conflict technique to estimate the traffic safety at unsignalized intersections (roundabouts) and an index measure was developed to summarize the conflict risk at intersections. This index provides an indication regarding the relative risk of being involved in a conflict at an intersection. These research efforts further enhance the usefulness of the traffic conflict technique as a tool to evaluate the safety of intersections. Safety and risks are not only described in mathematical terms, when studying traffic safety, it is also important to obtain knowledge concerning human behavior. Conflict studies are often combined with other types of behavioral studies. In order to estimate the number of accidents from conflict registration, ratios between the number of conflicts and accidents are used, which means that conflicts can also be regarded as a measurement of exposure, as well as an indirect estimate of the number of accidents. At intersections, observation or video-recording methods are used to estimate an exposure database for the number of vehicles or pedestrians using the area. The exposure data can be based on traffic situations, either registered accidents or by using traffic conflict techniques for the area. Combined with traffic counting systems, the accident rate or conflict rate can be expressed as the number of accidents per million vehicles entering the intersection. The traffic conflict technique enables one to study hazards in traffic in an uncomplicated way. It used to be the number of reported accidents at a site that decided whether it should be rebuilt or not. For following traffic conflicts in practice it is necessary to defined four basic questions:

a) Why to analyze traffic conflicts,
b) Conflict severity,
c) Types of traffic conflicts,
d) How to conduct a traffic conflict study.

a) Why to analyze traffic conflicts

A traffic conflict study can be used:

- to make progress in a safety diagnosis. Traffic conflict studies are particularly useful when accident data suffer from strong limitations (accident reports may be unavailable, the information may be insufficient or unreliable),
- to evaluate the effectiveness of a safety remedy. The main advantage of conflict studies over accident studies is that it is not necessary to wait several years before gathering sufficient data to complete the evaluation. A conflict study can be conducted soon after work has been completed and negated quickly if the anticipated benefits have not been achieved (or if unexpected side effects have been created). In these studies, traffic conflicts need to be observed before and after the implementation of the remedy,
- to compare the safety performance of different road features or traffic rules (e.g., to compare safety at signalized intersections with and without an exclusive left-turn phase).

b) Conflict severity

Most traffic conflict techniques (TCTs) categorize conflicts based on their severity (e.g., serious or non-serious). Some TCTs use subjective criteria to determine conflict severity; for example, the American manual developed by Parker and Zegeer (1989) identifies serious conflicts based on an array of observations that include vehicle front-end-diving when braking, squealing brakes, etc. Other TCTs determine conflict severity by using more objective criteria (which may, however, be more difficult to measure); for example, the Swedish traffic conflict technique combines the TCT and the vehicle speed to distinguish between serious and non-serious conflicts.

For the TCTs purposes three levels of conflicts have been defined. For the complex analysis of the studied locality even so-called level 0 and level 4 can be monitored. Thus there are 5 levels altogether (Figure 1). We will now describe the constituent levels of conflict severity.

The first level is level 0. This level is used for the record of an isolated vehicle merely breaking road traffic rules (in the case of the roundabout this kind of manoeuvre was, for example, not to signalize stream compulsory direction change while leaving the roundabout). The level 1 is assigned to the controlled manoeuvre without any limitation or just with a minor limitation. The example of this level is a conflict between a vehicle which is standing on the pedestrian crossing, for example, because of the traffic jam (this is not yet conflict level 1), and the pedestrian, who would like to use this pedestrian crossing, has to go around the vehicle (see the Figure 1 – level 1).

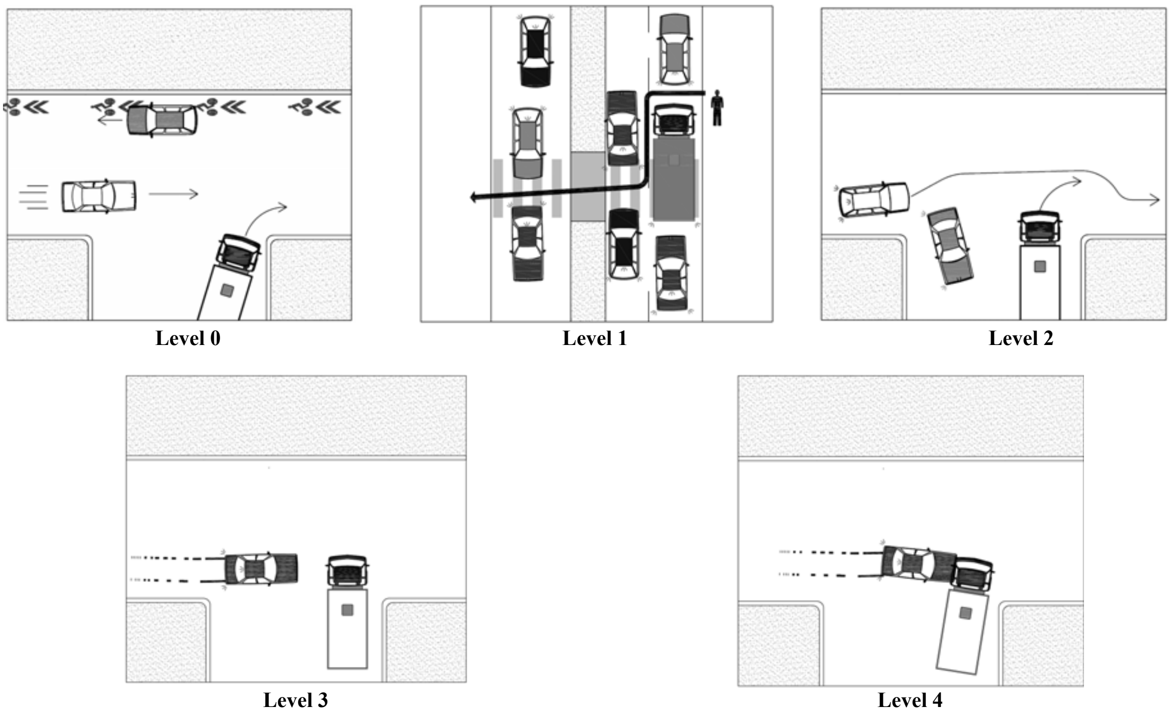


Figure 1: Example of conflict severity.

The difference between level 1 and level 2 is minor. In spite of that, it is necessary to realize, that in some specific situations (the example with pedestrians - see above) it is necessary to divide this kind of conflict into less severe and more severe (level 2). According to the Law n. 361/2000 on traffic on the road the term “not to be allowed to limit” is according to the §2 article m) defined as the duty of the driver not to obstruct another participant of the traffic. Conflict level 3 is assigned to such situations when the road users are threatened and a sharp manoeuvre (loud breaking, supplemented, for example, with sounding the horn) is necessary to avert a traffic accident (according to the Law n. 361/2000 on traffic on the road the term “not to be allowed to endanger”). Level 4 is an accident. An example of a traffic conflict record is below (Figure 2).

Traffic conflict record		**O / B - 1**	
		Problem creator / respond – conflict severity	
Comment			
O	personal vehicle	B	BUS
N	small cargo vehicle	T	tramway
NT	long vehicle	Ch / C	pedestrian / cyclist

Figure 2: Example of traffic conflict record.

c) Types of traffic conflicts

As in the case of accident analyses, it is quite useful to subdivide traffic conflicts into different categories, based on their type. This allows the preparation of summary tables, graphs and diagrams that facilitate the interpretation of results (comparisons with sites having similar characteristics and the detection of deviant types of traffic conflicts). Our research defined 14 types of conflicts between two vehicles (one of them is on Figure 3 - left) 1 example of secondary conflicts (Figure 3 - right).

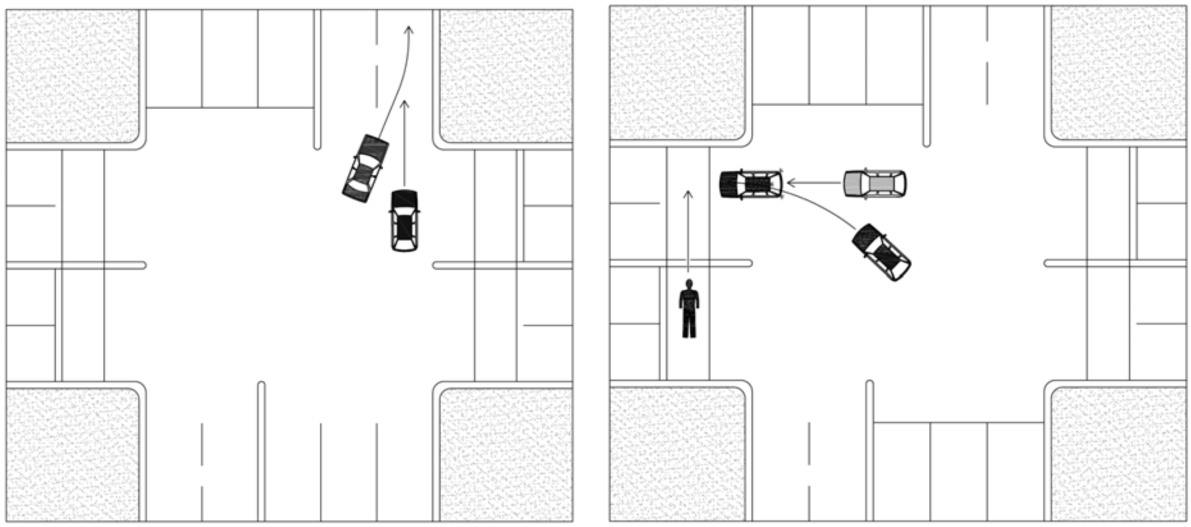


Figure 3: On the left is an example of one conflict between two vehicles - Lane change conflict;on the right is an example of secondary conflicts (from our catalogue 15 types of traffic conflicts).

However, some of these conflicts have very low rates of occurrence, which reduce their usefulness. The number of conflict types rises quickly when those that may occur between motorized and non-motorized road users are added to the list (pedestrians, cyclists, others). The list of conflict types that may be observed at a site depends upon its prevailing traffic rules and geometric characteristics; this list should be determined prior to initiating the study. It is not necessary to observe all traffic conflicts that may occur at a site in all conflict studies. If, for example, the objective is to compare the performance of two left-turn treatments at intersections, it might very well be sufficient to collect conflicts that are related to this manoeuvre.

d) How to conduct a traffic conflict study

A number of elements need to be considered in the planning of a traffic conflict study:

- personnel training
- observation technique
- observation period

Personnel training

The validity and usefulness of a traffic conflict study are greatly influenced by the degree of consistency of the observers. Two basic requirements must be satisfied- the same observer must record conflicts consistently and different observers must record the same conflicts consistently.

Observation technique

The required number of observers (or the study duration when observations are made sequentially) depends on the number of conflict types to be observed, the average rate of occurrence for each conflict type, the volume of traffic, the number of intersection legs, and the need for a traffic count.

When all traffic conflict types need to be collected at a busy intersection, one observer will generally be able to watch only one intersection leg at a time. We can use mechanical or electronic counting devices (to facilitate data collection) or video camera, recording media, etc. (the recording of traffic conditions while conducting a conflict study is useful in later validating questionable conflicts or completing observations). Observations are generally made upstream from the location of the traffic conflicts of interest, in order to see vehicles' braking lights. Observers' exact location is influenced by the availability of space, the presence of obstructions to visibility, the types of conflicts to be observed, and the traffic speed. A distance of 30 m or more from the point of interest is usually adequate in urban areas (100m or more in rural areas). Observers should try to be inconspicuous to drivers to avoid modifying their behaviour. Appropriate locations include legal parking spaces, sitting behind a utility pole or a tree, etc. When allowed by the site configuration, observations should be made from an elevated point (e.g., the roof of a building) to avoid some visual obstructions (group of pedestrians, parked vehicles, etc.). When the observation period extends over several days, observers should try to maintain the same position throughout the study. When similar conflict studies need to be conducted at different sites, observers should try to use equivalent positions.

Observation period

In most cases, traffic conflict studies are conducted during daylight under dry weather conditions; observations should not be made under unusual conditions, such as road works, or special events that interfere with normal traffic patterns, unless justified by the need of the analysis.

- If accident analyses reveal a time-related pattern, observations should be planned when problems are the most likely to be observed (rush-hour periods, weekends, etc.).
- The observation period may vary from a few hours to several days, depending on the time needed to collect sufficient data. Typical observation periods range

from between two to five days. Statistical methods have been developed to determine a study duration that will ensure a selected level of statistical reliability

- In order to help observers maintain a high level of concentration, a conflict study must be planned around sequences of observation periods and breaks. Parker and Zegeer (1988).
- If the vehicle intensity in peak hours is below 100 rv/h (reduction vehicle per hour), it is necessary to pursue metering longer than 1 hour.

3 APPLICATION

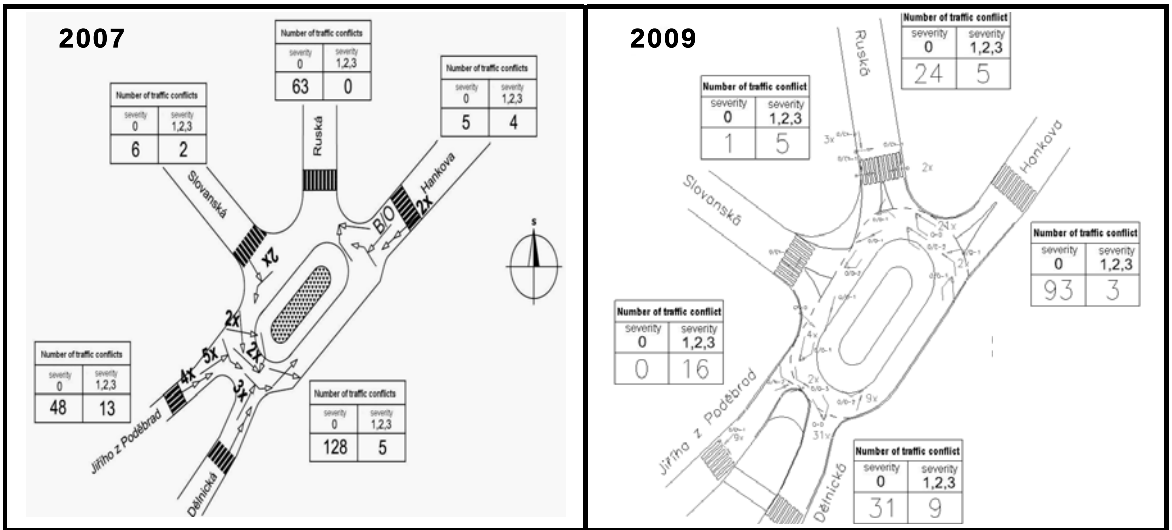
Before initiating the analysis, the observer must complete all the information on the traffic form heading to ensure that the location and observation conditions will be readily recognized in the future: municipality, intersection, approach, date, time, weather conditions and other comments.

Once observations have been completed, data must be reduced and summaries prepared. Results are presented either in summary tables or in traffic conflict diagrams (Figure 4). Summary tables allow comparisons of conflict rates between the site being analyzed and sites with similar characteristics, which is useful in detecting deviant patterns. The logic behind these analyses is similar to that of the accident pattern analysis. Traffic conflict diagrams are quite similar to the collision diagrams. They facilitate the identification of repetitive conflict patterns that are concentrated in some travel directions and intersection areas. For the likelihood of a confrontation of traffic conflicts between separate junctions the simple relative index of traffic conflicts $\mathbf{k_R}$ was chosen.

$$\mathbf{k_R = (P_{ks}/I) * 100} \text{ [conflict situations /100 reduction vehicles]}$$

P_{ks} ... conflict situations per hour (only conflict situations with a conflict severity 1-3),
I... intensity rv/h (reduction vehicle per hour).

A pilot survey made in Děčín at the roundabout “Dělnická . Hankova – Ruská” with students of the Czech Technical University in Prague, Faculty of Transportation Science, Department of Transporting Systems (Figure 4).



conflict situations according to conflict severity				conflict situations according to conflict severity			
0	1	2	3	0	1	2	3
250	12	7	5	149	24	12	2
relative index of traffic conflicts kR [conflict situations /100 rv]							
k_R =(24/1417)*100=**1,69**				**k_R** =(38/1233)*100=**3,08**			

Figure 4: Example of one roundabout in Děčín. Junctions have a degrade relative index of traffic conflicts (1.69 – 2007, 3.08 – 2009). Relative index of traffic conflicts in year 2008 was 2.37 conflict situations /100 rv.

4 DISCUSSION AND CONCLUSION

The article deals mainly with defining a way of monitoring traffic conflicts. This issue is only one part of a greater safety analysis, or the risk determination process of a particular location. Based on the described procedures it is also possible to apply the methodology to more complicated nodes such as level crossings, sections of towns, residential areas, or rural areas. After the survey and collection of the necessary amount of transport and engineering data, the determination of a relative number of “almost-accident rate” (the number of calculated vehicles for a selected time period and the number of traffic conflicts – so-called almost-accidents) may be calculated. At this stage, the overall risk result of the monitored node may not yet be stated. An important inter-stage is therefore, determination of an initial or safe state of a proved type of measure (e.g., ring crossings) and the deduction of generally valid hypotheses. The last step is the determination of a “risk parameter” of the problematic node. As a result, the crossing either passes or fails (the risk parameter is either good or bad). The part of the risk parameter will be dealt with by the Czech Technical University in Prague, Faculty of Transportation Science, Department of Transporting Systems, within its research task for the upcoming period.

ACKNOWLEDGMENT

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Modeling Traffic Information using Bayesian Networks

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ABSTRACT: Dutch freeways suffer from severe congestion during rush hours or incidents. Traffic congestion increases travel time, resulting in a delay for travelers. To avoid these delays, rerouting traffic around congested areas is an option. Reliable travel time predictions are essential for dynamic routing and travel information. Travel time can be calculated from vehicle speed measurements (van Lint, 2004). These speed measurements are acquired from dual inductive loop detectors collected by the Dutch Monitoring Casco (MONICA) data system. In this paper, the predictability of average vehicle speed by Bayesian Networks is investigated in a case study. We propose a general Bayesian Network model and evaluate several simplified versions of this model on a well known traffic bottleneck in the Netherlands. We show that our Bayesian Network is capable of predicting the start and end of a congestion for a prediction horizon of 30 minutes with an accuracy of 14%. Furthermore, we present a prediction model based on historical data which is evaluated on the same bottleneck. This prediction model based only on historical data and our Bayesian Network are combined in a hybrid model, where we evaluate performance as well. This hybrid model is able to predict congestion with an accuracy of 85% for a rather long prediction horizon of 2.5 hours in our case study.

KEY WORDS: Bayesian Networks, prediction, vehicle speed, inductive loop detector data.

1 INTRODUCTION

Many highways in the Netherlands suffer from severe congestion at some times of the day. Regular congestions can be anticipated, but incidental congestions will increase people's travel time and raise frustration. Travel times are important for travelers, as well as for road managers. Accurate travel time predictions give travelers or road managers the ability to anticipate road congestion and to estimate their arrival time.

Travel time τ for a certain route can be computed as follows:

$$\tau = \sum_{i=1}^{N} \frac{d_i}{V_i} ,$$

where d_i denotes the distance and V_i denotes the travel speed on subsection i respectively and $1 \le i \le N$. The fact that speed V_i is actually a function of time is disregarded for convenience purposes at this moment. There are different approaches for traffic prediction: an instantaneous approach, a model based approach, or data driven approaches. Instantaneous approaches assume that traffic conditions remain stationary for the time the prediction holds (van Lint, 2004). In general, traffic does not remain stationary if time passes (Lindveld & Thijs, 1999).

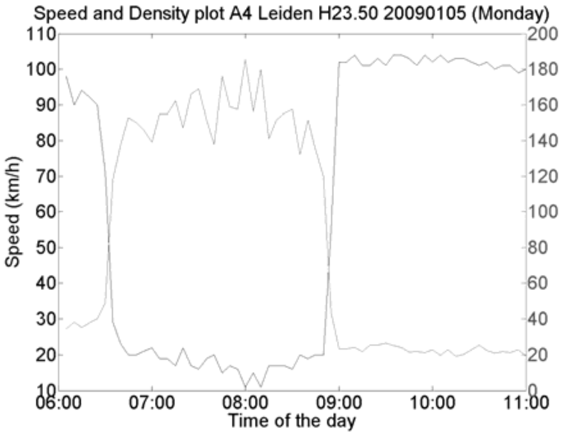

Figure 1a: Combined speed and density graph.

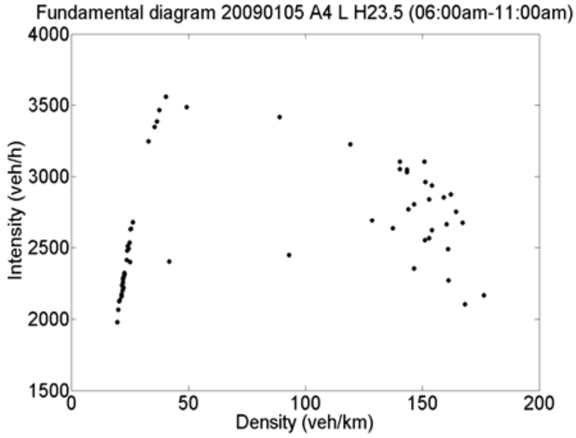

Figure 1b: Combined intensity and density graph.

Most congestion occurs during the morning or evening rush hours. Therefore, accurate speed predictions for these periods are essential. About 64% of the traffic during congestion consists of commuter traffic (Rijkswaterstaat, 2006). This group of travelers certainly benefits from accurate travel time predictions to plan their day.

Traffic propagates in space and time and is influenced by its context, such as weather, events, accidents, road works, or other incidents which makes traffic an uncertain domain. Bayesian Networks allow us to reason about an uncertain domain (Korb & Nicholson, 2004). We believe that there are strong correlations between traffic measurements such as speed or density at different locations. Furthermore, we have to deal with missing values, which are a common problem in traffic research (van Lint, 2004). Bayesian Networks can handle incomplete datasets and allow one to learn about causal relationships (Heckerman, 1995).

Traffic speed, density, and intensity represent traffic situations. Only two of these variables need to be known to be able to calculate the other. The Bayesian Network we propose in this paper incorporates density and speed measurements. Figure 1a shows a combined graph of speed and density from a morning rush hour at one location of the A4 highway in the Netherlands. This figure shows a switch point, where the speed decreases and the density increases. Figure 1b shows a combined data plot of intensity and density measurements on the same location at the A4 motorway. This figure shows that the intensity (flow) decreases when the density increases. There is an unstable traffic situation just before the congestion. We expect that congestion cannot be seen in these graphs a few hours beforehand, and therefore we combine our Bayesian Network with a historical data model in a hybrid model (Van Den Haak et al. 2010).

The outline of this paper is as follows. Section 2 details related work. In Section 3 we present our models. A description of the data is given in Section 4, and this data is used in our experiment which is described in Section 5. In Section 6 we present the results of our experiment and in Section 7 we present our conclusions and discussion.

2 RELATED WORK

Different approaches on modeling traffic with Bayesian Networks can be found in literature (Sun et al. 2004), (Sun et al. 2005), (Sun et al. 2006), (Yu & Cho, 2008). These approaches only include one traffic variable in their network, either traffic flow or traffic speed. Figure 2 shows a road network and the corresponding Bayesian Network model developed by Sun et al. (Sun et al. 2004) for predicting traffic flow with incomplete data. Each circle is a node where travelers can change direction. This model predicts traffic flow (intensity) at D_d and it is assumed that flow measurements at D_d for previous times influence the prediction. Furthermore, upstream links C_e, C_g, and C_h for different time instants also influence the prediction. Yu et al. (Yu et al. 2008) propose a Bayesian Model which includes upstream links as well as downstream links.

Our Bayesian Model differs since it includes speed as well as density measurements combined with historical data predictions in a hybrid model.

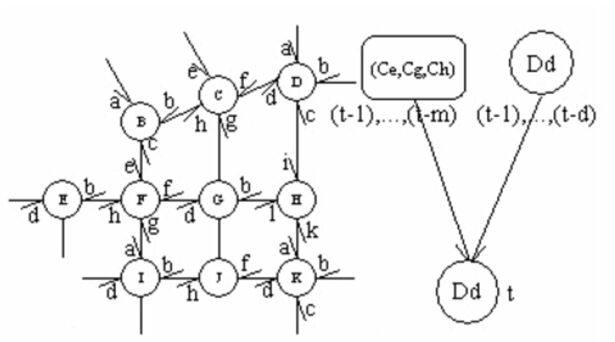

Figure 2: Bayesian Model proposed by Sun et al. (Sun et al. 2005).

3 PREDICTION MODELS

We propose a Bayesian Network which incorporates speed and density measurements for multiple locations and multiple time instants. Figure 3 shows a graphical representation of this model for *k* locations and *i* time instants. We have used GeNIe & SMILE from the Decision Systems Laboratory of the University of Pittsburgh to model, train and test our Bayesian Model. If multiple locations and time instants are incorporated, the model quickly becomes complex and computationally expensive to train. To cope with this problem, our Bayesian Network is kept simple and is connected to an adaptive prediction model which is based on historical data in a hybrid model.

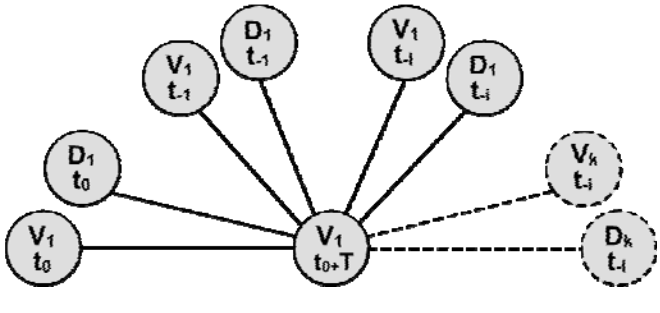

Figure 3: General Bayesian Network.

a. Bayesian model

At this stage of research, we propose a simplified version of our general Bayesian Model for our experiment. This model incorporates speed and density measurements for three different locations at the A4 highway in the Netherlands. The causal nodes take speed and density measurements at time t_0. This model is trained for different prediction horizons T, where $T \geq t_0$. We expect that this Bayesian model is able to predict short term congestion. In this paper, short term predictions lie in the range from 5 to 30 minutes.

b. Historical model

We propose an adaptive learning prediction model based on historical data. This model searches a database with traffic models of speed and density for every location. The model database contains mean patterns of four different clusters: (1) Monday-Thursday, (2) Friday, (3) Weekend and (4) Holiday, and the raw data which is not clustered. These clusters have been found during an explorative data analysis for homogeneous clusters in the traffic data. Figure 4a and Figure 4b show examples of the models for speed and density respectively.

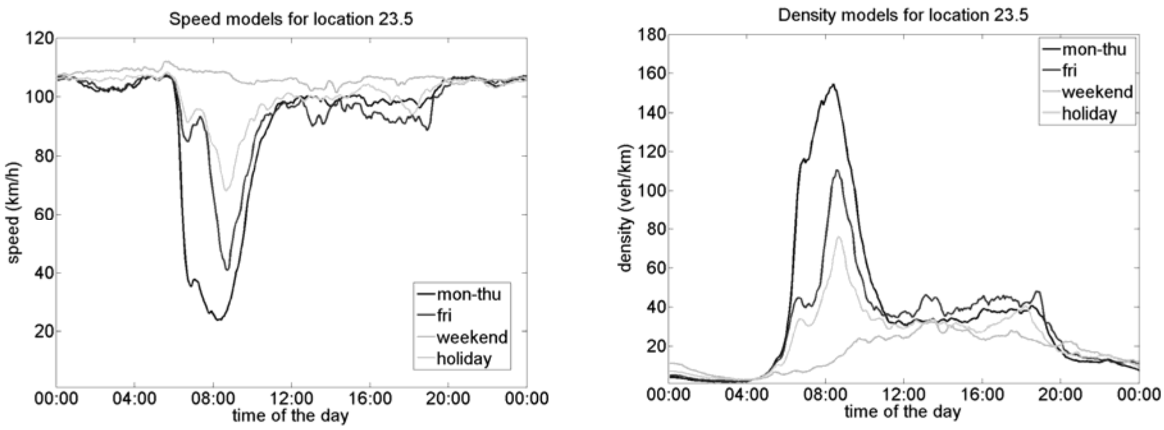

Figure 4a: Speed models. **Figure 4b: Density models.**

Figure 5a shows an example cluster of speed measurements from a location at the A4 in the Netherlands for a total dataset containing 365 days of 2009. Figure 5b shows the cluster containing only Tuesdays for the same location. This figure shows that the data becomes more homogeneous after clustering.

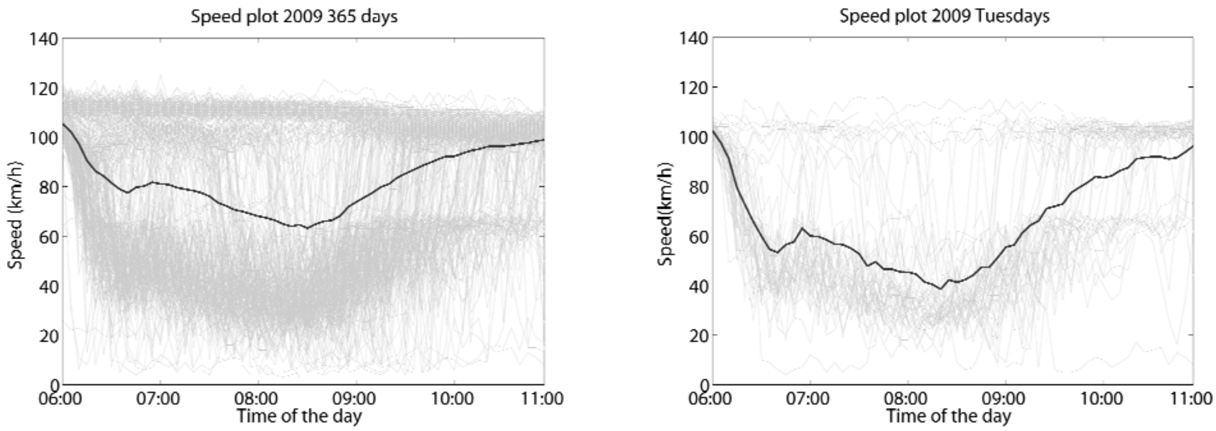

Figure 5a: Cluster for 365 days. **Figure 5b: Cluster for Tuesdays.**

Our prediction model based on historical data is adaptive since it is able to find the best fitting clustered model when new data becomes available. It also tries to find a best fitting day in the total data which is not clustered. This dataset is likely to contain typical days containing accidents, extreme weather, or other incidents. Therefore, our model is able to adapt to new situations continuously. We expect that our adaptive prediction model based only on historical data is able to predict congestion for longer prediction horizons.

c. Hybrid model

We propose a hybrid model, in which we use historical data in our adaptive prediction model to compute initial predictions for speed and density for a prediction horizon T_h. These initial predictions are the input for the three locations in our Bayesian Model. Our Bayesian Model then predicts for a horizon of T_b, based on these initial predictions from the historical data of our adaptive learning prediction model. In total, we have a prediction horizon $T = T_h + T_b$. We expect that traffic congestion is not visible in the data a few hours ahead, and therefore we first conduct a prediction based on historical data for several locations. These initial predictions are given to our Bayesian Network which is able to model the relations between the locations on the road. We therefore expect our hybrid model to predict traffic congestion for long prediction horizons (from 60 to 150 minutes) accurately.

4 INDUCTIVE DUAL LOOP DETECTOR DATA

Real traffic data is one of the most important elements in analyzing and improving traffic systems. Real data gives us a better representation of the situation compared to simulated data. Traffic flow is often measured by inductive loop detectors (ILD) because of their widespread availability (Vanajakshi, 2004). The Dutch freeway system is equipped with inductive dual loop detectors, which are capable of measuring speed and intensity per lane. An example of an ILD can be found in Figure 6. The data of these detectors are collected in the Monitoring Casco (MONICA) data system, managed by the Dutch Ministry of Transport, Public Works, and Water Management.

In general, the MONICA data systems contains on average 12% missing values (van Lint, 2004), due to maintenance, accidents, and power or communication failures. To decrease the size of the dataset and the number of missing data points, our dataset has been aggregated from lane data to road data. This aggregation procedure takes the harmonic average over the lane measurements. We choose to take the harmonic mean, because speed measurements are used as a rate when calculating travel times. More details about computing the average of vehicle speed can be found in (van Lint, 2004). The intensity value for a road is the summation of the intensities per lane. The missing values in our data are filled in by the Treiber and Helbing filter (Treiber & Helbing, 2002), which reconstructs the spatio- and temporal traffic characteristics.

5 EXPERIMENT

We tested our models on an important traffic bottleneck in the Netherlands at the A4 from The Hague to Amsterdam around hectometer location 23.5 at the left side. The capacity of the road decreases from 3 lanes to 2 lanes which results in traffic congestion during rush hours or incidents. Figure 7 shows a schematic overview of this test location. Location A, B and C represent the locations in our Bayesian Network model.

A dataset has been extracted out of the MONICA data system for the year 2009 for locations A, B and C. A train and a test set has been randomly selected out of the 365 days. The train set contains 80% (292 days) and the test set contains 20% (73 days) from the total set.

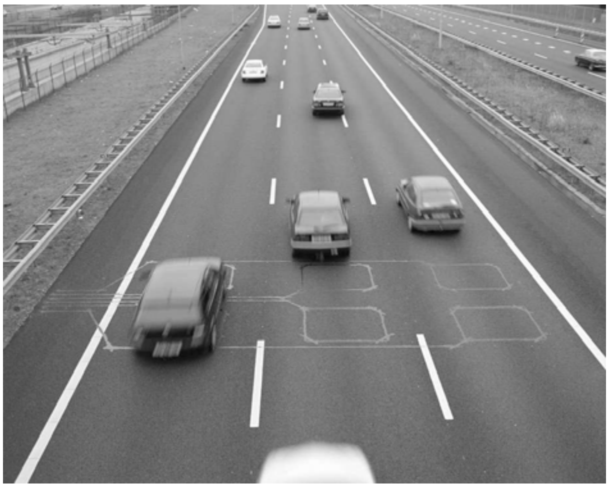

Figure 6: Example picture of an ILD (Taale, 2006).

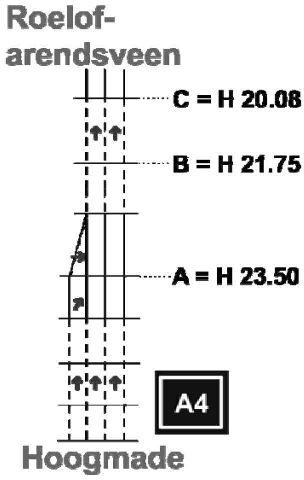

Figure 7: Schematic overview.

The Bayesian Network is trained for different time horizons, and evaluated for the corresponding time horizon. For this paper, all our models have been evaluated.

The sMAPE is used to compute the difference between the real data and the predicted data as follows:

$$sMAPE = \frac{1}{N}\sum_{t=1}^{N}\left|\frac{A_t - F_t}{A_t + F_t}\right|,$$

where A_t is the actual value and F_t is the forecast value at time t and $1 \le t \le N$. Since this measure only tells us the relative distance over all time instances, we need another measure to evaluate if our models are able to detect congestion.

Therefore, we introduce a measure for false positives and false negatives. False positives denote a situation in which the prediction model predicts a congestion, while there is none. False negatives denote a situation in which the prediction model predicts no congestion, while there is one. The general aim is the keep the false negatives low, as an error here would result in unexpected congestions which is not desirable for travelers.

For comparison purposes, we introduce another model: the Naïve model. This model only takes all speed values until the current time t_c and assumes that traffic remains stationary. This model can be expressed as follows: $V_{c+T} = V_c$ and will be referred to as the Naïve model.

6 RESULTS

The result of the sMAPE, the false positives and the false negatives percentage for the Bayesian Network model, are presented in Table 1. This table shows that our Bayesian Network has a slightly lower false negatives percentage, but is comparable to the Naïve Model.

Table 2 shows the results for our adaptive learning model based on historical data. The results show that our adaptive learning model outperforms the Naïve model when the prediction horizon increases. The results of the hybrid model are presented in Table

3. This table shows that our hybrid model clearly outperforms the Naïve model on the false negatives percentage. This means, that our hybrid model is clearly better in predicting congestion then the Naïve model.

Table 1: Experiment results for the Bayesian Network.

T	sMAPE Bayesian Network	sMAPE NAÏVE	FP Bayesian Network	FP Naïve	FN Bayesian Network	FN Naïve
5	3 %	3 %	4 %	4 %	5 %	7 %
10	5 %	5 %	8 %	6 %	4 %	12 %
15	6 %	6 %	7 %	7 %	7 %	15 %
20	7 %	7 %	12 %	9 %	10 %	18 %
25	7 %	7 %	13 %	10 %	12 %	20 %
30	8 %	8 %	14 %	11 %	14 %	21 %
35	8 %	9 %	15 %	12 %	15 %	22 %
40	9 %	9 %	15 %	13 %	20 %	24 %
60	12 %	11 %	19 %	18 %	29 %	29 %
120	11 %	15 %	11 %	28 %	35 %	47 %

Table 2: Experiment results for the adaptive prediction model based on historical data.

T	sMAPE Historical model	sMAPE Naïve	FP Historical model	FP Naïve	FN Historical model	FN Naïve
60	14 %	16 %	13 %	15 %	35 %	38 %
120	17 %	24 %	17 %	19 %	41 %	66 %

Table 3: Experiment results for the hybrid model.

T	sMAPE Hybrid	sMAPE Naïve	FP Hybrid	FP Naïve	FN Hybrid	FN Naïve
65	16 %	17 %	19 %	16 %	14 %	50 %
70	16 %	18 %	21 %	17 %	12 %	42 %
75	17 %	19 %	22 %	18 %	13 %	44 %
80	17 %	20 %	24 %	19 %	12 %	47 %
85	17 %	21 %	24 %	20 %	14%	48 %
90	18 %	21 %	24 %	21 %	15 %	50 %
125	16 %	25 %	25 %	20 %	17 %	68 %
130	16 %	25 %	27 %	21 %	15 %	70 %
135	17 %	26 %	28 %	22 %	14 %	72 %
140	17 %	26 %	29 %	23 %	12 %	74 %
145	18 %	27 %	29 %	24 %	14 %	76 %
150	18%	27 %	29 %	25 %	15 %	77 %

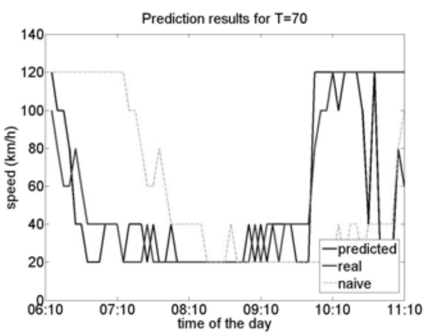

Figure 7a: Example result for T=70.

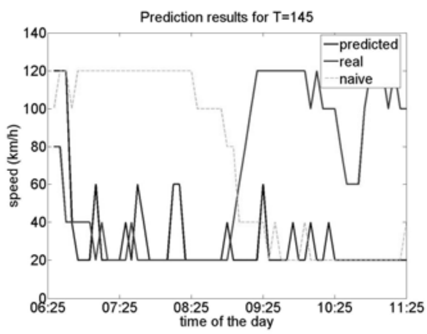

Figure 7b: Example result for T=145.

Figure 7a and Figure 7b show an example of a prediction plot for T=70 and T=145 respectively for the hybrid model. Figure 7a shows that our hybrid model is able to predict the start and end of the congestion accurately for 70 minutes ahead. In the middle of the congestion, the prediction shows stochastic behavior. Figure 7b shows that for longer prediction horizons it becomes more difficult to predict congestion.

7 CONCLUSIONS & DISCUSSION

In this paper we showed that our Bayesian Network is able to perform comparably to the Naïve model. The Naïve model only makes an error if the traffic changes, and therefore is shown to be a strong comparator. Our adaptive learning model is able to predict traffic congestions for longer horizons in which it outperforms the Naïve model. The combination of historical models and our Bayesian Model is shown to be a powerful one. Our hybrid model clearly outperforms the Naïve model.

We show that the results of our hybrid model are promising. It would be interesting to test our models on more locations for different datasets to see if this conclusion can be drawn for other situations as well.

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Usage of Scanning Electron Microscopy for Particulate Matter Sources Identification

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ABSTRACT Particulate matter (PM) diameter and shape are the most discussed physical properties considering behaviour characterisation, source identification, and possible effects on human health. Some groups of particles not only have a typical chemical composition but also a specific shape reflecting the method of their formation, so it is possible to deduce the source. A scanning electron microscope VEGA TS 5136 LSU (Tescan, s.r.o., Czech Republic) was used for PM imaging. PM air samples were captured on Millipore special filters made of polycarbonate membrane (Isopore) with a 0.6 µm size of pores. PM samples were taken both from near the exhaust of gasoline and diesel engines to define PM shapes emitted from combustion processes in vehicles, and also from chosen localities that represent urban sites with different traffic intensity and with different possible PM sources (transportation, industry). Samples of street dust were also collected by sweeping with a broom and with a vacuum cleaner to identify PM generated by resuspension. Separate spherical particles were observed on exposed filters near a gasoline vehicle's exhaust pipe and their aggregates near a diesel vehicle's exhaust. Spherical particles aggregates were also observed on filters exposed at a locality with a high traffic intensity where road traffic is considered to be the dominant source of air pollution. Larger spherical particles that represent the products of coal combustion were found at a locality near an industrial area. Other particle shapes, excluding spherical particles, were often observed at the localities that represent a more open area with more trees. Sharp-edged particles of geological origin (soils) and larger spherical or elongated particles of biological origin (spores) were also often observed on the filters from these localities which is evidence of a significant contribution of other processes to the overall PM air pollution, namely resuspension.

KEYWORDS: Particulate Matter, Morphology, Scanning Electron Microscopy, Sources.

1 INTRODUCTION

Particulate matter (PM) is considered to be a mixture of chemical components originating from a variety of sources with specific physical parameters (such as shape, diameter, electric charge, solubility, surface of the particles) and chemical composition (organic and inorganic compounds). Sources, mechanisms of formation, meteorological conditions, distance from the source and other conditions determine these basic parameters (US EPA, 2004a, US EPA, 2004b). Knowledge about the physical properties of particles is important for the characterization of their behaviour, source identification, and possible health risks. The diameter and the shape are the most discussed from this point of view, because these properties determine PM hazardousness. The shape determines the PM incidence on the cell walls of the respiratory system, and the diameter determines whether the particle can be inhaled and in which part of the respiratory system it can be deposited (Weijer et al., 2001). Coarse particles and parts of fine particles (2 – 10 μm) are deposited in the extra-thoracic and the trachea-bronchial areas, while particles smaller than 1 μm penetrate into the pulmonary alveoli and can be deposited there. Many recent studies state in their conclusion clear evidence that air pollution by particulate matter significantly contributes to an increase in the risk of respiratory symptoms and diseases and risk of death due to cardiopulmonary causes, especially in the population of children younger than five years (Dockery et al., 1994; Kunzli et al., 2000, Pope, et al., 2002; Krzyzanowsky et al., 2005). Knowledge about particles' shape and diameter obtained by the analysis of individual particles with an electron microscopy yields important information for accurate source identification and leads to a more complete estimation of exposure (Weinbruch, Ebert, 2004). Hence the electron microscopy is a very effective method for PM sources apportionment (McCullum, Kindzierski, 2001, Chong et al., 2002, Zonping et al., 2003, Casuccio et al., 2004, Chen et al., 2005, Senlin et al., 2008).

Research described in this paper involves the analysis of particulate matter loading in urban ambient air and was conducted to characterize source contributions to the overall PM air pollution with the primary interest in determining the transportation share.

2 METHODS

2.1 PM and street dust sampling

Middle volume aerosol samplers LECKEL MVS6 (Sven Leckel Ingenierbüro, Germany) equipped with inlets for the separate sampling of PM fractions, were placed at three different locations in an urban environment. The first locality was a street valley with high traffic intensity (36,000 vehicles per day) where road traffic is considered to be the dominant source of air pollution. The second one represents a more open area with family houses in surroundings with less traffic intensity (9,000 vehicles per day). The third locality is placed approx. 100 m far from the busy road and represents a residential neighbourhood with family houses with a lot of green areas close by. Industry is considered to be the dominant source of pollution due to an industrial area placed close by in the south-east of this locality. Local heating and soil resuspension could also significantly contribute to PM air pollution at the last two localities. PM sampling was carried out during the summer and winter seasons. Filters were exposed for 1 hour to capture only one layer of particles which is suitable for shape observations. PM air samples were taken with the special Millipore filters made of polycarbonate membrane (Isopore) with the 0.6 μm size of pores with perfectly smooth surface designed specially for the scanning electron microscopy (SEM) purposes. To define more precisely particles produced by fossil fuel combustion in vehicle engines in chosen localities, PM were captured using low volume samplers Aircheck2000 (SKC inc., USA) next to the vehicles' exhaust pipe (cca. 2 cm distance). The measurement was carried out for a comparison of both gasoline engine (Opel Astra 1.6 l. manufactured in 2000, covered distance 291,779 km) and diesel engine (Škoda Octavia 1,9 TDi, manufactured in 2005, covered distance 85,099 km). Samples of street dust were collected by sweeping with a broom and with a vacuum cleaner next to the road at the first locality and also from a parking place next to the family house in the third locality to identify PM generated by resuspension. The street dust was then fractionated into 3 size intervals 100-400 μm, 50-

100 μm and ≤ 50 μm. Particles smaller than 50 μm can be removed from the surface by wind or turbulence caused by moving vehicles.

2.2 SEM analysis

Imaging of PM was carried out using the scanning electron microscope VEGA TS 5136 LSU (Tescan s.r.o., Czech Republic) that permits both a low vacuum and a high vacuum mode of measurements with a resolution up to 3.5 nm. The surfaces of the exposed filters and street dust samples placed on the carbon plaster were coated with a 20 nanometres thin layer of gold to divert the arising charge from the place of the impact of the electron beam by using the device Bal-Tec SCD 050 (Bal-Tec, Lichtenstein). This permits imaging of the PM at a magnification of 100 thousand at a very good quality, suitable for the precise determination of the PM shape. Prepared samples were observed in high vacuum mode (0.02 Pa) with a cathode high voltage of 30 kV. Low-energy secondary electrons that are ejected from the k-orbital of the specimen atoms by inelastic scattering interactions with beam electrons were used for imaging. The brightness of the signal depends on the number of secondary electrons reaching the detector. If the beam enters the sample perpendicular to the surface, then the activated region is uniform about the axis of the beam and a certain number of electrons are emitted from the sample. As the angle of incidence increases, the emission distance of one side of the beam will decrease, and more secondary electrons will be emitted. Thus steep surfaces and edges tend to be brighter than flat surfaces, which results in images with a well-defined appearance.

3 RESULTS AND DISCUSSION

Spherical particles were observed, as was expected, at the samples collected next to the exhaust pipes of both vehicles. The spherical particles are shown in fig. 1. Separate spherical particles produced by the combustion of fossil fuel in vehicles' engines (soot) are approx. 50 nm in diameter. PM emitted by the diesel engine create more aggregates of spherical particles growing up to 2 μm in diameter (image on the right in fig. 1) whereas in gasoline engines exhaust gases PM are more isolated and aggregates are less common (image on the left in fig. 1).

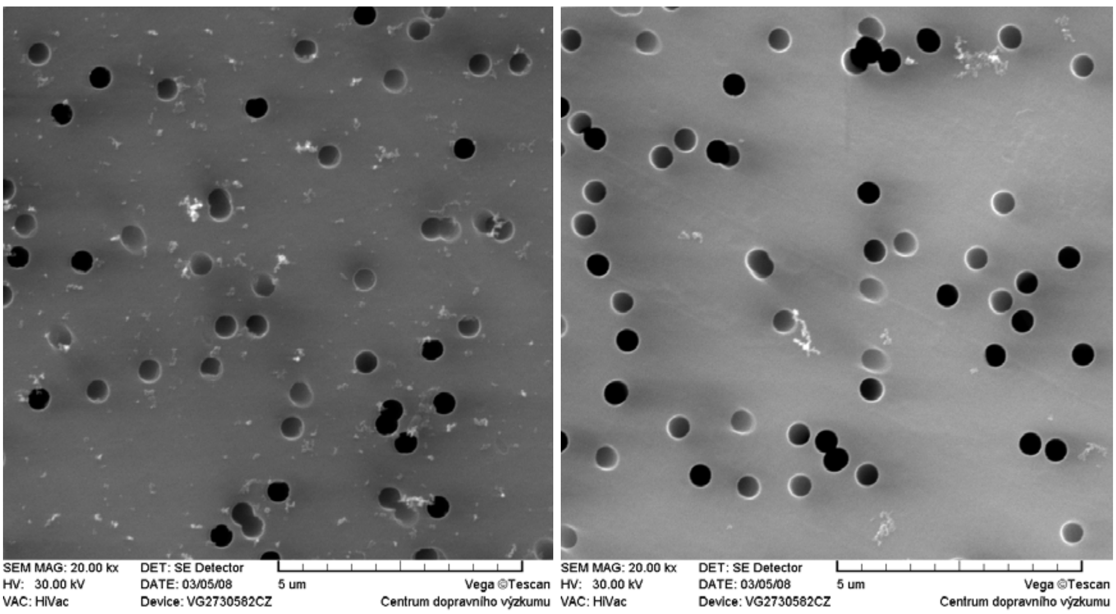

Figure 1: PM emitted by gasoline (on the left) and diesel engine (on the right).

Street dust samples collected on localities 1 and 3 are represented entirely by sharp-edged particles in all fractions (image on the left in fig. 2). They are dominant especially in the size fraction smaller than 50 µm that can be easily removed from a surface by the wind or the turbulence caused by moving vehicles. Fractions larger than 50 µm also contain organic material particles, probably mechanically separated parts of plants (image on the right in fig. 2).

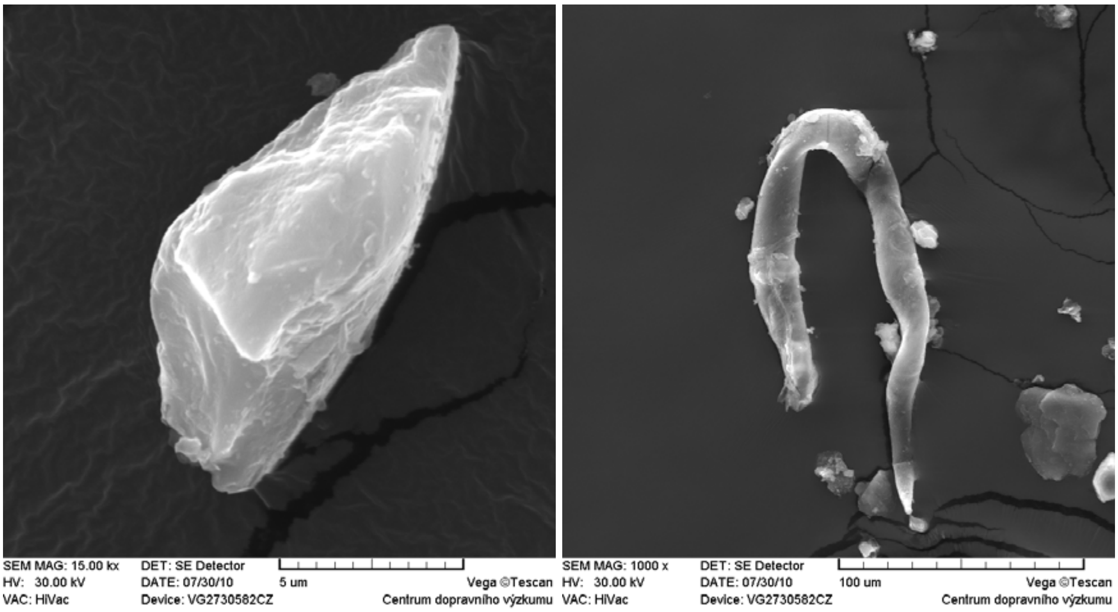

Figure 2: Street dust particle in fraction smaller than 50 µm (on the left) and organic particle in street dust fraction 50 – 100 µm (on the right).

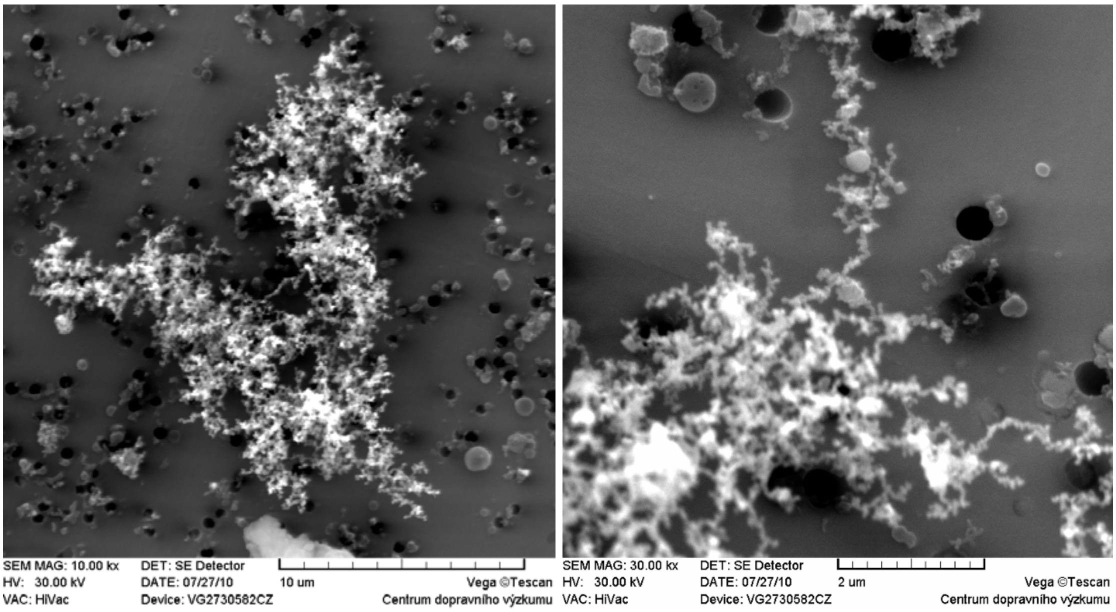

Figure 3: Spherical particles aggregates (on the left) and detail of the basic structural element (on the right).

Similar spherical particles (soot) as those captured next to exhaust pipes with a diameter of about 50 nm coagulated to the larger aggregates were the most frequently observed ones in the samples of ambient air taken on the first locality with high traffic intensity during both sampling seasons (fig. 3). This fact indicates the traffic as a dominant source of air pollution by PM at this site. Diameters of these aggregates are up to 20 µm, which indicates their origin in the atmosphere far away from exhaust pipes.

Sharp-edged and cubic or cubical particles were also observed on filters exposed on the first locality. The abrasion of vehicles break-shoe lining and stressed bodies parts (image on the left in fig. 4) or wear of tyres, road pavement or parts of material (sodium chloride) used for the road maintenance in winter season (image on the right in fig. 4) could be the sources of these particles.

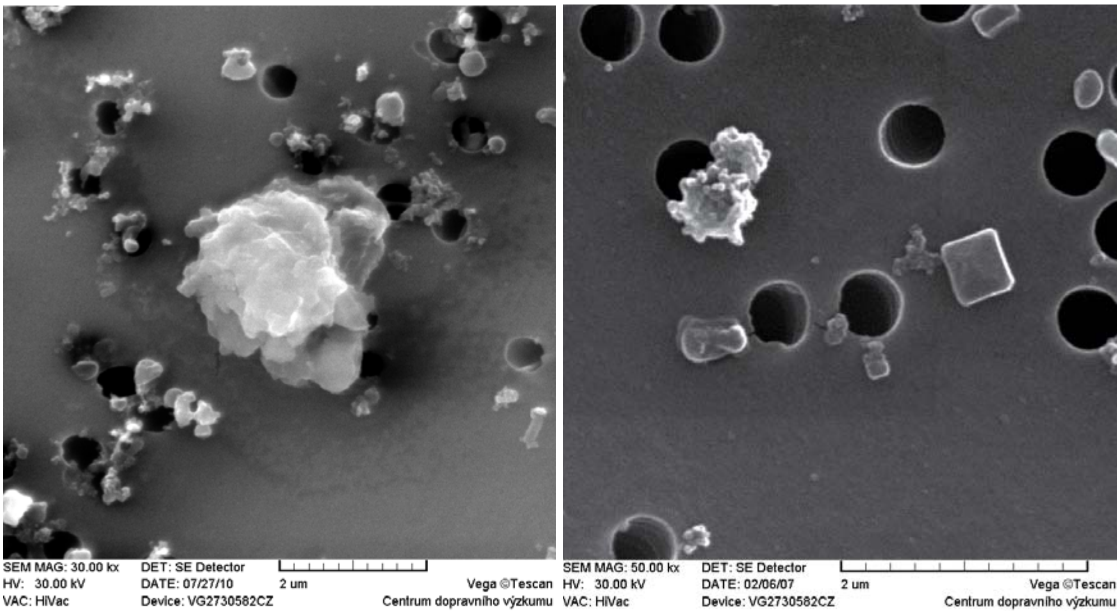

Figure 4: Particle mechanically separated from highly stressed car accessories (on the left) and cubic particle of material used for road maintenance (on the right).

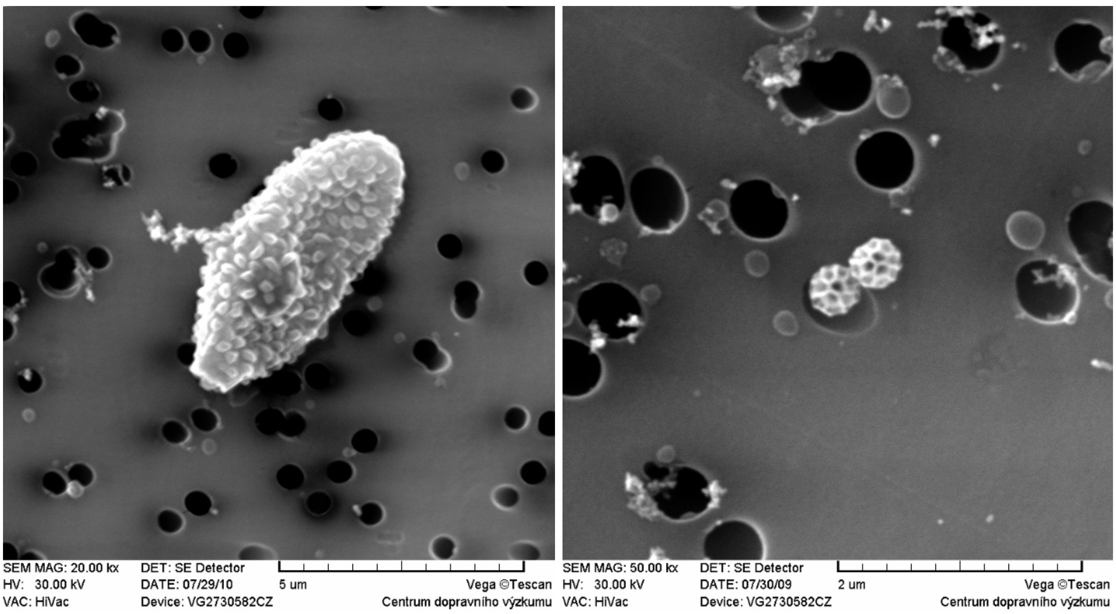

Figure 5: Particles of biological origin.

Biological particles were also found on filters exposed during the summer sampling campaign on this locality, namely in coarse PM fraction, PM10 (image on the left in fig. 5), but several of them were also observed in smaller PM2.5 fraction. The image on the right in fig 5 shows brochosomes cover which is produced by leafhoppers (Cicadellidae) (Shi et al., 2003, Casuccio et al., 2004).

The same particle types as in locality 1 were also observed on the other localities but in different shares of the total amount. Spherical particles with a diameter of about 50 nm coagulated to the larger aggregates (soot) were also found on the second and the third locality but in much smaller amount than at locality 1. Apart from these spherical particles larger spherical particles were often observed with a diameter of between 0.5 and 1.5 µm on filters exposed in locality 3 (fig. 6). These particles represent fly ash from industrial production near this locality and prove thus the significant contribution of this source to overall PM air pollution in this locality.

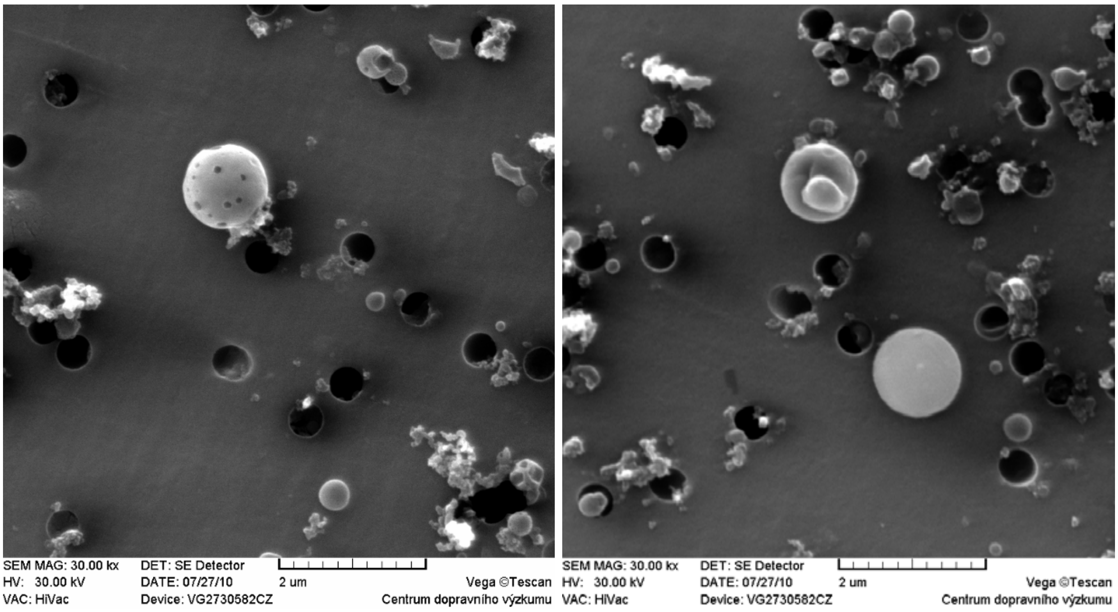

Figure 6: Particles from industrial production.

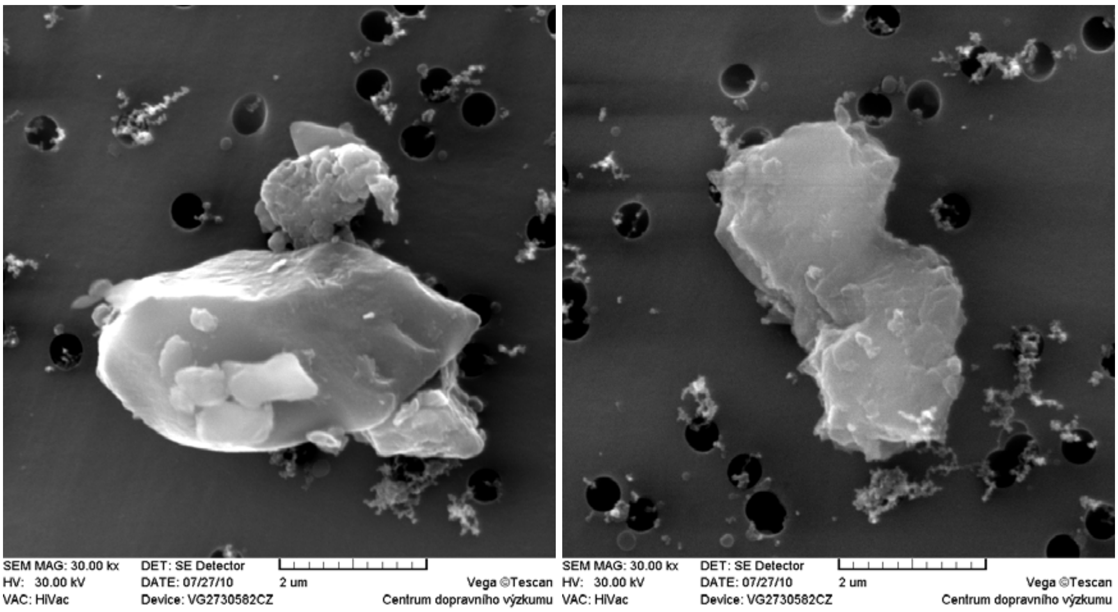

Figure 7: Resuspended geological particles.

Sharp-edged particles significantly occurred on filters exposed at locality 2 and 3, more wide open areas with more greenery. These particles are very similar to those observed in collected street dust samples and hence represent particles of geological origin resuspended from the surface (fig. 7).

The occurrence of these particles proves the significant contribution of other sources to overall PM air pollution on the second and the third locality, particularly the resuspension processes and industrial emissions (i.e., coal combustion) with the exception of transportation (i.e., fuel combustion).

4 CONCLUSIONS

Several sources contributing to overall PM air pollution were found at chosen localities on the basis of image observations using SEM. Fuel combustion processes are the dominant source of PM pollution at locality 1 with a high traffic intensity and are represented by spherical particles with a diameter of about 50 nm, coagulated to the larger aggregates (soot). Sharp-edged particles representing abrasion of vehicles' break-shoe lining and stressed bodies' parts or geological particles resuspended from the surface also significantly occurred at this locality. Resuspension seems to be the dominant source of PM air pollution at localities 2 and 3; however, coal combustion at the industrial area near locality 3 significantly contributes to PM air pollution and is represented by larger (0.5 – 1.5 μm in diameter) spherical particles (fly ash).

Scanning electron microscopy (SEM) is an effective tool (cheaper and faster than chemical analysis) for the identification of PM sources. However, for more proper PM sources identification it is suitable to combine the knowledge on separate PM morphology with the chemical composition of PM by association of SEM with an Energy Dispersive X-ray analyzer that allows the measurements of elements concentrations in micro volume of the solid materials. PM origin interpretation only on the basis of morphology characterization without the chemical composition knowledge could, in some cases, be inaccurate or misleading. Therefore the obtained results presented in this paper were compared with data published in scientific literature and impact journal articles in which the same PM shapes were observed and assigned to a specific source, also on the basis of chemical composition, and correlate well with them.

ACKNOWLEDGEMENTS

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Technical Notes on Participation on the Balloting Process of ASTM International

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DOI: 10.2478/v10158-010-0020-2

INTRODUCTION

ASTM International is one of the largest voluntary standards development organizations in the world. It is a trusted source for the technical standards for materials, products, systems, and services. There are over 130 ASTM technical committees covering diverse industry areas ranging from metals to the environment. The author of the technical note is a balloting member of five of them. They are:

- Committee C09 on Concrete and Concrete Aggregates
- Committee D04 on Road and Paving Materials
- Committee D18 on Soil and Rock
- Committee D35 on Geosynthetics
- Committee E07 on Non-destructive Testing

The above-mentioned committees balloted about 425 documents, see Table 1.

Table 1: Number of Ballots in Specified Committees.

Ballot	**Number of Ballots**				
	Committee C09	Committee D04	Committee D18	Committee D35	Committee E07
1.10	21	28	54	7	40
2.10	55	5	26	1	7
3.10	69	21	15	14	20
4.10	23	3	10	-	-
5.10	-	3	-	-	-
6.10	-	2	-	-	-
Sum in the Committee	169	62	105	22	67
Total Sum in Specified Committees	425				

The objective of the Technical Note is to inform about the selection of technical problems solved by the above-mentioned committees in 2010 from the author's point of view. It is neither an official nor comprehensive report from the life of the committees.

Committee C09 on Concrete and Concrete Aggregates

The committee was balloting about new standards, guides and practices or their revisions. The following ones seem to be interesting as relates to actual domestic tasks: Specifications for silica fume used in cementitious mixtures, guide for the evaluation of alternative supplementary cementitious materials for use in concrete, test method for the flexural toughness of fiber reinforced concrete, practice for laboratories testing concrete and concrete aggregates for use in construction and criteria for laboratory evaluation, test method for the water retentivity of grout mixtures for preplaced-aggregate concrete in the laboratory, practice for estimating concrete strength, terminology relating to concrete and concrete aggregates, specification for admixtures to inhibit chloride-induced corrosion of reinforcing steel in concrete, test method for static segregation of self-consolidating (compacting) concrete and test method for the density and void content of freshly mixed pervious concrete.

Committee D04 on Road and Paving Materials

Asphalt and bituminous materials have taken up a large part of the committee's effort, i.e., test methods for the compressive strength of bituminous mixtures, test methods for the resistance to deformation and the cohesion of bituminous mixtures by means of Hveem apparatus, practice for the preparation of test specimens of bituminous mixtures by means of gyratory shear compactor, test method for the preparation and determination of the relative density of Hot Mix Asphalt (HMA) specimens by means of the Superpave Gyratory Compactor, practice for the preparation of bituminous specimens using the Marshall apparatus, test method for the bulk specific gravity and density of non-absorptive compacted bituminous mixtures, etc.

Committee D18 on Soil and Rock

The Committee has been involved in the preparation or revisions of test methods, guides and other documents, such as a guide to site characterization for engineering design and construction purposes, a guide for site characterization for environmental purposes with an emphasis on soil, rock, the vadose zone, and ground water, practice for the surface site characterization for on-site septic systems, a guide for the analysis of spatial variation in geostatistical site investigations, a guide for using the electronic cone penetrometer for environmental site characterization, practice for the assembly and placement of double-twisted wire mesh gabions, a guide for coring and logging cement - or lime-stabilized soil, etc.

Committee D35 on Geosynthetics

Interesting test methods, guides, practices, and other documents were discussed in the Committee, e.g., test method for measuring the nominal thickness of geosynthetics, test method to determine asphalt retention of paving fabrics used in asphalt paving for full-width applications, test method for pore size characteristics of geotextiles by capillary flow test, test method for determining the flow rate of water and suspended solids from a geotextile bag, a guide for the installation of geosynthetic clay liners, a guide for considerations when evaluating direct shear results involving geosynthetics, a guide for the selection of test methods for flexible polypropylene geomembranes, etc.

Committee E07 on Non-destructive Testing

The non-destructive testing committee has been involved in various documents, i.e., a guide for computed radiography, practice for the qualification and long-term stability of computed radiology systems, a guide for the use of UV-A and visible light sources and meters used in the liquid penetrant and magnetic particle methods, a guide for determining the reproducibility of acoustic emission sensor response, a test method for the examination of fiberglass reinforced plastic fan blades using acoustic emission, practice for the examination of gas-filled filament-wound composite pressure vessels using acoustic emission, etc.

SUMMARY AND ACKNOWLEDGEMENT

The Technical Note informs about selected problems solved by ASTM International, what an author considers interesting from his point of view. Comprehensive information about ASTM International can be obtained from their website www.astm.org. An author's participation in ASTM International is partly supported by the grant of the Ministry of Education, Youth and Sports of the Czech Republic no. LA 09007.

Instructions to the autors

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.

4.1 HEADINGS AND SUBHEADINGS

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.

4.2 FIGURES AND TABLES

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.

4.3 REFERENCES

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.

More details can be found at **www.transportsciences.org**.

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