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Human Factor Case – Tool for Systematic Identification and Management of Human Factor Issues for Air Traffic Management Project

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ABSTRACT: This paper presents human factor as a crucial element of flight safety. It is a generally known fact that human factors play an important role in incidents and accidents in aviation, especially regarding pilots and technical personnel, as well as air traffic controllers. The amount of air transport grows dramatically year by year as the saturation of air traffic service airspace similarly increases, filled with sporting (amateur) aviation, military, and other flights (aero-medical, sightseeing flights, etc.). The relationship between human performance and safety has been a long-standing issue with Air Traffic Control authorities, since human performance is considered to be a critical determinative for Air Traffic Management safety.

KEY WORDS: Human Factor, Human Performance, Air Traffic Management.

1 INTRODUCTION

At sharp end of performance in Air Traffic Management (ATM), professionals manage their own performance at a tactical level – controllers, supervisors, engineers, etc. Behind the scenes, other groups of professionals and means contribute to the improvement of human performance at a more strategic level. These elements use various principles and methods for measuring and influencing human performance – directly or indirectly. Three “enablers” of human performance in ATM are noteworthy (see Figure 1).

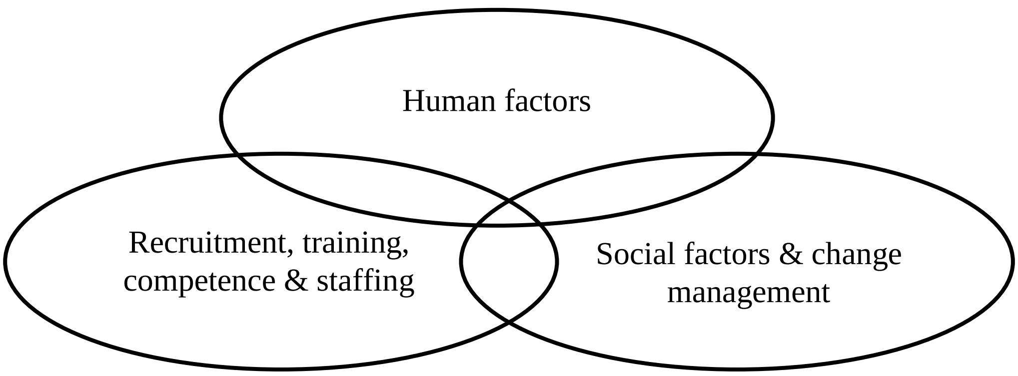

Figure 1: Delivering human performance benefits.

- Human Factors (HF) is a design-oriented discipline and profession which develops and applies the knowledge about the performance of people at work towards the design of the work. It focuses on the task requirements, the equipment and technology people use, the rules and procedures they work under, the ways in which they communicate, and the physical and organisational environment in which they operate. HF focuses mostly on "fitting the job to the person". HF issues are also classified as HF Impacts on Human Performance (see Figure 2).

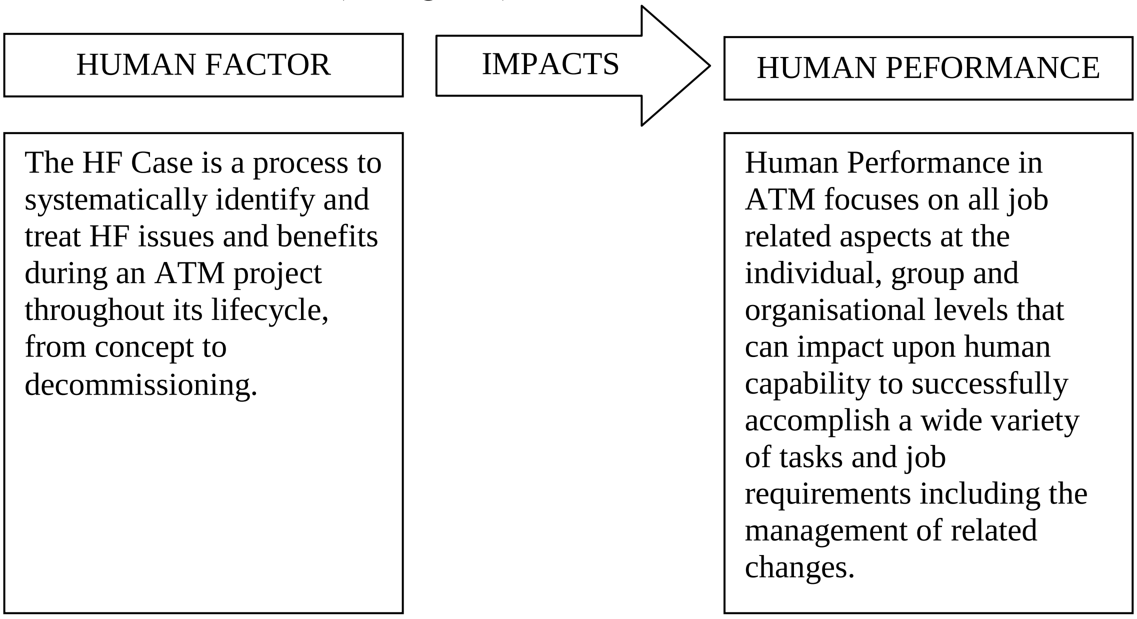

Figure 2: Relation between Human Factors issues and Human Performance.

- Recruitment, training, competence, and staffing are the primary concerns of human resource management (HRM) and occupational and organisational psychology. The priorities are to attract and retain talented and competent staff, as they will ultimately determine the success and sustainability of the organisation. HRM and psychology focus more on "fitting the person to the job".
- Social factors and change management refers to a social dialogue and change process, which will pave the way forward for future concepts if accepted and recognised by all parties involved and affected by the changes.

All three enablers secure the compatibility or "fitness" between people, their work, and the organisation, regardless of the differing focus of each issue. They overlap in the introduction of large-scale changes, such as the Single European Skies ATM Research (SESAR) in Europe, NextGen in the US, and Automatic Dependent Surveillance-Broadcast (ADS-B) in Australia and Canada.

2 HUMAN FACTOR CASE

The HF Case is a management tool which systematically identifies and manages HF issues and manages HF issues for an ATM project. It can be divided into five stages (see Figure 3).

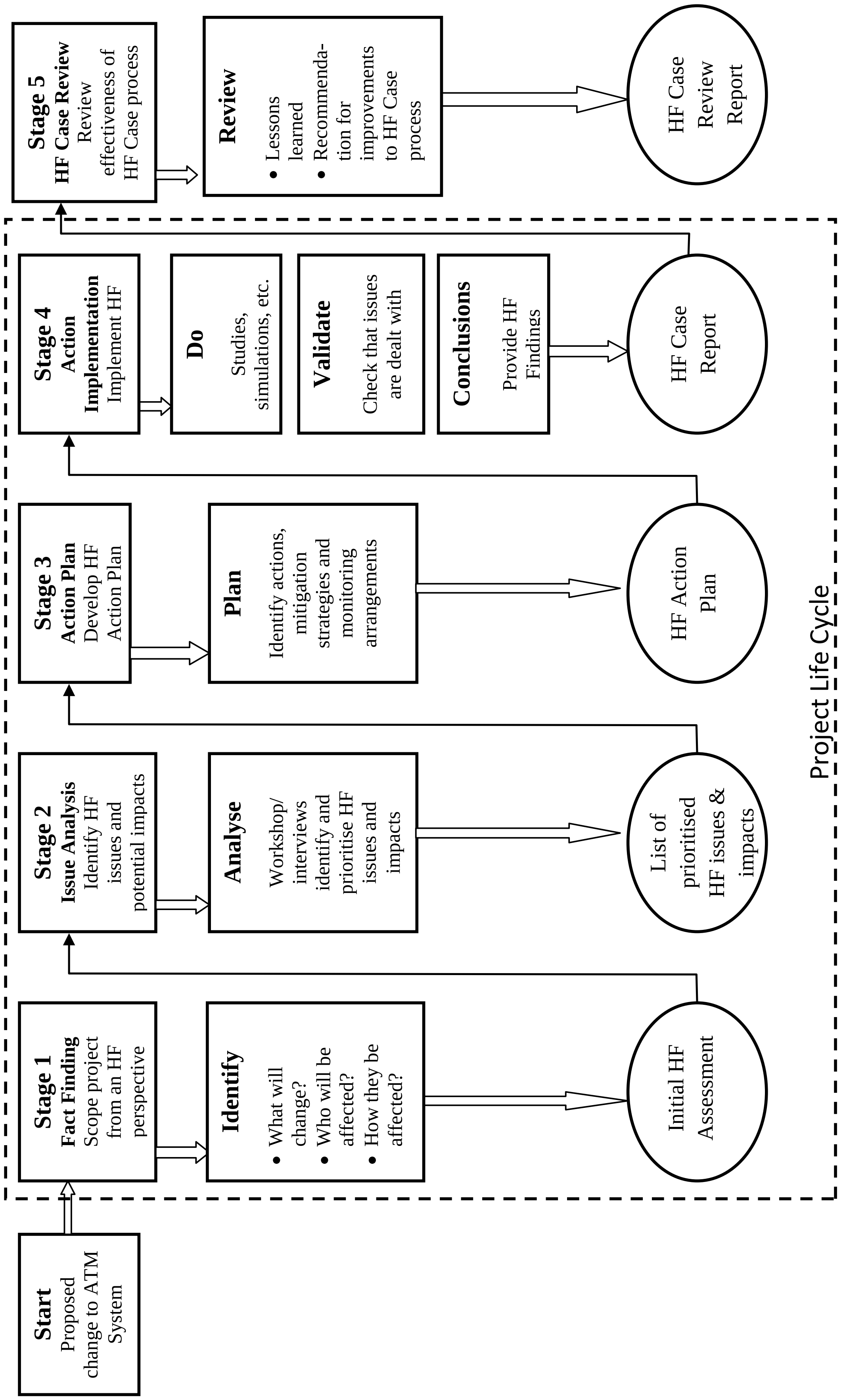

Figure 3: Stages of Human Factors Case.

It provides and enables:

- A framework to address HF issues
- The application and integration of subject matter expertise and HF knowledge
- A comprehensive qualitative analysis

The HF Case process provides:

- An explicit way to manage HF issues
- A checklist and traceability for HF issues as the project evolves
- Ownership within the project team for HF
- Facilitates decision making to justify resources and budget for HF
- Minimises the risk of HF issues popping up at a critical stage

This means that HF Case is aimed at:

- Programme and Project Managers – Providing assurance that HF is integrated into the project and there is awareness among the project team.
- Validation – Allows them to track HF issues from simulations and experiments.
- Safety – The HF Case is complementary to a Safety Case and may help them identify safety relevant issues for the Safety Case.
- Training and Staffing – Develops an awareness of staffing and training issues that may need to be tackled later in the project life cycle.

2.1 Human Factor Pie

To facilitate the identification of issues related to human factors within a project, HF issues are classified into the following six main categories, called the "HF Pie". The HF Pie underlies the general approach to the identification, assessment and monitoring of HF issues relevant to the project. They are displayed in the diagram below (Figure 4). By investigating each element of a given category, the analytic team can identify issues relevant to a specific project.

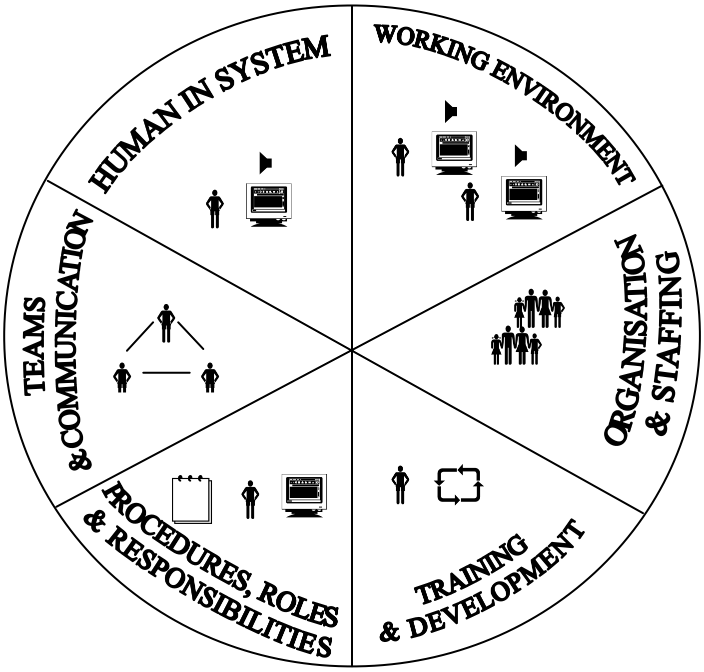

Figure 4: Human Factors Pie.

3 HUMAN PERFORMANCE CHALLENGES FOR FUTURE AIR TRAFFIC MANAGEMENT

The future of Air Traffic Management (ATM) will depend on the ability of the industry to handle a number of critical challenges concerning human performance. Six key challenges are outlined below.

3.1 Designing proper technology

Future technology will be a step change from current technology. The focus will shift to collaboration across sectors and centres, and between ground and air to support the shared “situation awareness”. Tools will also need to accommodate more advanced planning and look-ahead time, while supporting the flexibility required to deal with unplanned situations. At the same time, it must be ensured that it is possible to handle unexpected disturbances and degraded modes safely. Crucially, the automation must keep the human operator in the loop to be able to maintain control – and thereby safety – in all circumstances.

3.2 Selecting the right people

Major technological and organisational changes may require changes to the type and number of people required to operate the business effectively. This may require changes to manpower planning, recruitment, and selection to ensure that we have the right people, at the right numbers, at a time.

3.3 Organising the people into the right roles and responsibilities

A new collaborative approach to ATM will result in new roles and responsibilities for controllers and engineers, as well as for other ground staff. In light of increased delegation, such changes will extend to flight crews. Roles are likely to be more fluid than is the case today. The human performance implications of transitioning between roles must be clearly understood and managed.

3.4 Ensuring that the people have the right procedures and training

New technology, people, roles, and responsibilities all impact the training and procedures required, both for new and existing staff. Competencies will also need to be maintained for old skills that may be used more rarely in light of new technology, but are still critical when needed. The new collaborative approach to ATM may require new collaborative approaches to training.

3.5 Managing human factors processes at a project and ANSP level

Consideration of human performance issues requires human factors to be fully integrated with system development and safety management. The management goals are to meet the demands for efficiency, enabling capacity gains and safety improvement. Performance indicators can be useful here, to benchmark and quantify the maturity of human performance assurance at an organisational level.

3.6 Managing the change and transition process

A successful project depends on a successful change and transition process, where the social, cultural, and demographic factors impacting performance are considered alongside the technical and procedural factors.

ATM today is one of very few “high reliability industries”. Throughout the major changes of the future, we need to keep it this way. Strategic, management-level approaches are necessary to maintain performance throughout every stage of the design, development and implementation process, before reaping the performance and safety benefits during the operations phase. The right management systems and organisational culture, including safety culture, will help to ensure that the capacity, efficiency and safety benefits expected are realised.

4 HUMAN PERFORMANCE AND ORGANISATIONAL BUSINESS PERFORMANCE

Compared to the other high-hazard industries, such as chemical processing, nuclear power, and even aviation more generally, air traffic management still remains “human-centred”. Despite advances in technology, ATM is still critically dependent on the day-to-day performance of highly skilled front-line personnel, such as controllers, engineers, supervisors, and other operational staff. Operational personnel safely and efficiently handle millions of flights, and effective human performance at the front line ensures this happen. Human performance solutions are required to bring the people, procedures, and equipment together effectively (see Figure 5) in order to make running the business more efficient and safer.

In terms of SAFETY, 2006 and 2009 were the safest years on record worldwide. 2008 was the fifth consecutive year without ATM-related accidents in Europe. Traffic growth is the key challenge to maintaining such a record, because when traffic doubles, risk is squared. The European SESAR programme aims to improve the safety performance by a factor of 10 by 2020. Clearly, the human element will be critical to ensuring that safety is maintained.

The industry needs to gain additional CAPACITY and reduce delays to meet the demands of traffic growth. The SESAR programme aims to enable a 3fold increase in capacity. Again, this can only be achieved when those managing the traffic are considered.

A third priority is EFFICIENCY. SESAR aims to reduce the costs of ATM services to airspace users by 50%.

These improvements make significant demands on human performance, but the financial benefits will be significant. According to the European ATM Master Plan, the savings attributable to direct ATM cost reduction, capacity gain and departure delay savings, as well as predictability improvement in case of low visibility conditions, is around €19bn for commercial airlines by 2020, with an additional €12.5bn of savings through passenger travel time.

To achieve the right fit, it is necessary to assert proper professional resources in the organisation. Whilst HRM and platforms for social dialogue are more commonplace, HF expertise in ATM is less so. Nevertheless, a number of ANSPs now have specific teams of qualified human factors specialists, integrated into design, selection, training, and safety functions. Some also have human performance teams comprising operational and engineering staff with a special interest in the domain. As human performance issues are a key driver of ATM performance, they need to receive considerable attention in planning, design, operations and maintenance, and should be treated as seriously as other business-critical functions.

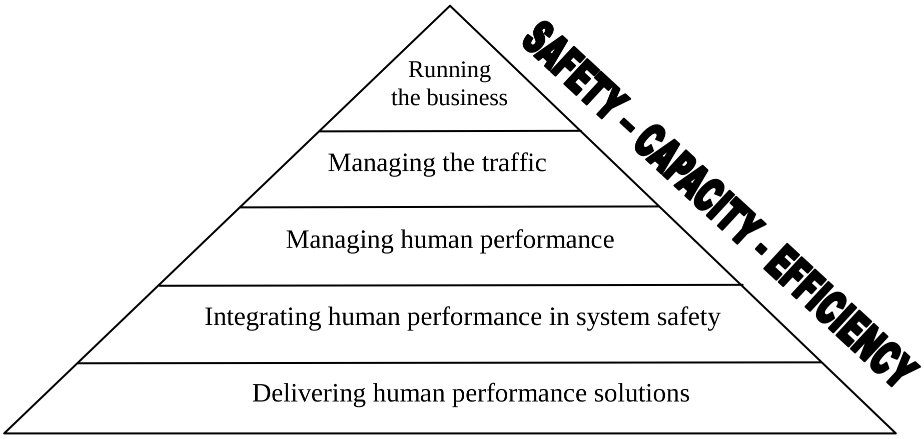

Figure 5: Human performance and organisational business performance.

5 UNDERSTANDING HUMAN PERFORMANCE

Human performance at work has been the subject of intense research in several disciplines for decades. Much is now known about how people perform tasks, and why they perform them in the way that they do. But much of this is hidden away in books and journals for academics and specialists.

Human performance, in the context of ATM, refers to the adequate performance of jobs, tasks, and activities by operational personnel – both individually and together. As a domain, human performance focuses on optimising the people element in complex work systems, such as air traffic management. Designing for human performance and managing human performance involves the application of knowledge gained from research and practice in human factors, psychology, and management.

Human performance depends on both the person and the context of work. Capability refers to the basic characteristics of the individual, e.g., aptitude, abilities, skills, physical capabilities, knowledge, experience, and health. Capabilities are assessed during selection and promotion, shaped and enhanced via training, and considered in the design of jobs, task/activities, systems, and tools.

Motivation and attitude influence the use of the person's capabilities. While a person's motivation varies, it is critical in ensuring that capabilities are fully realised in human performance. Motivation, attitude and trust can be improved significantly with the right approach.

The systems, organisation, and environment provide the opportunity for good performance, given sufficient capability and motivation, and include systems and technology, the design of the job and tasks, the workplace environment, training and procedures, and management and support. These can be designed and managed directly.

All three components have to be considered carefully. Even very highly capable individuals will not perform well if motivation is low or if the system, organisation or environment (e.g., training and procedures) are poor. Similarly, even the most motivated person, with good training and procedures, may not perform well if capabilities are poorly matched to the job requirements. Human performance can vary, positively or negatively, depending on the capability, motivation, system support, organisation, and environment.

6 CONCLUSION

In ATM, human performance and safety are inextricably linked. While the disciplines involved in improving human performance are themselves continually developing and improving, the techniques to identify and resolve these issues exist. They need to be embraced and integrated into the systems developers' and project managers' "mindsets" and practices.

As ATM continues to evolve in terms on NextGen improvements in the US, and Single Sky, Functional Airspace Blocks and SESAR in Europe, this will create new challenges for human performance and safety, as well as generating system performance advantages.

It is perhaps obvious that safety depends on human performance, and that they need to work together. What is less clear sometimes is how they can work together in practice. This paper has aimed to describe that there are techniques, approaches, and data sources which allow a strong synergy to take place between these two disciplines which share a common goal. It is hoped that it may encourage ANSPs, their managers, engineers, safety, and human factors professionals and researchers, to find effective ways to work together so that ATM can continue to enable aviation to remain the safest system of public transport, now and in the future.

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Noise from Rail Transport within the European Legislation on Interoperability

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ABSTRACT: This paper is focused on rail transport and the environment, particularly the relationship between noise from rail transport and the directives of the European Union. There are two main areas of legislation on traffic noise originating from the European Commission – Interoperability Directives and Environmental Noise Directive. At the beginning of this paper the noise sources from rail transport are noted. The following sections of this paper present the Directives on interoperability and their historical development. This paper focuses mainly on the role of noise from rail transport in Interoperability Directives. Lastly, the possible measures for reducing noise from rail transport are mentioned.

KEY WORDS: Rail transport, noise, interoperability.

1 INTRODUCTION

Traffic noise is a serious consequence of transport on the environment. 1996 was a breakthrough year when a core document Green Paper on EU Future Noise Policy was drafted under the European Union. The main goal of this document was to improve the noise situation in the environment. Among the important documents dealing with traffic noise are the directives on interoperability. These directives aim at accelerating the integration of the European Union rail network through increased technical harmonization, thereby guaranteeing a high level of safety. This harmonization also brings with it a significant reduction in noise.

2 NOISE FROM RAIL TRANSPORT

Noise is one of the key issues of all transportation, including rail transportation. Rail noise originates mainly from three main sources. The first one is rolling noise, causing by wheel-rail interaction. Then there is the power equipment noise, caused by locomotive engine, gears, and fans, and lastly there are aerodynamic effects. Sources of rail noise are represented in Figure 1. Rail exterior sound sources depend on train speed (see Figure 2 (Hemsworth, 2008)).

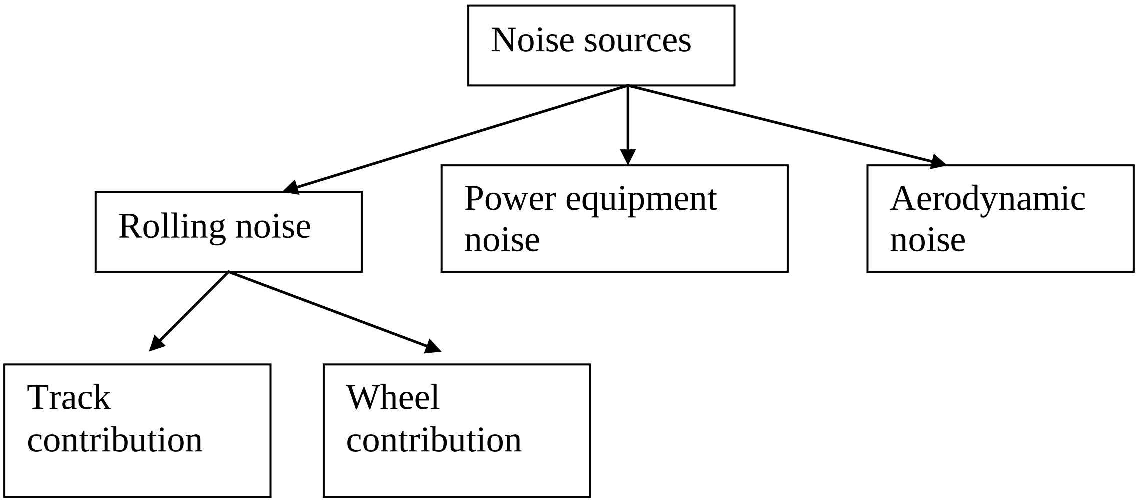

Figure 1: Noise sources from rail transport.

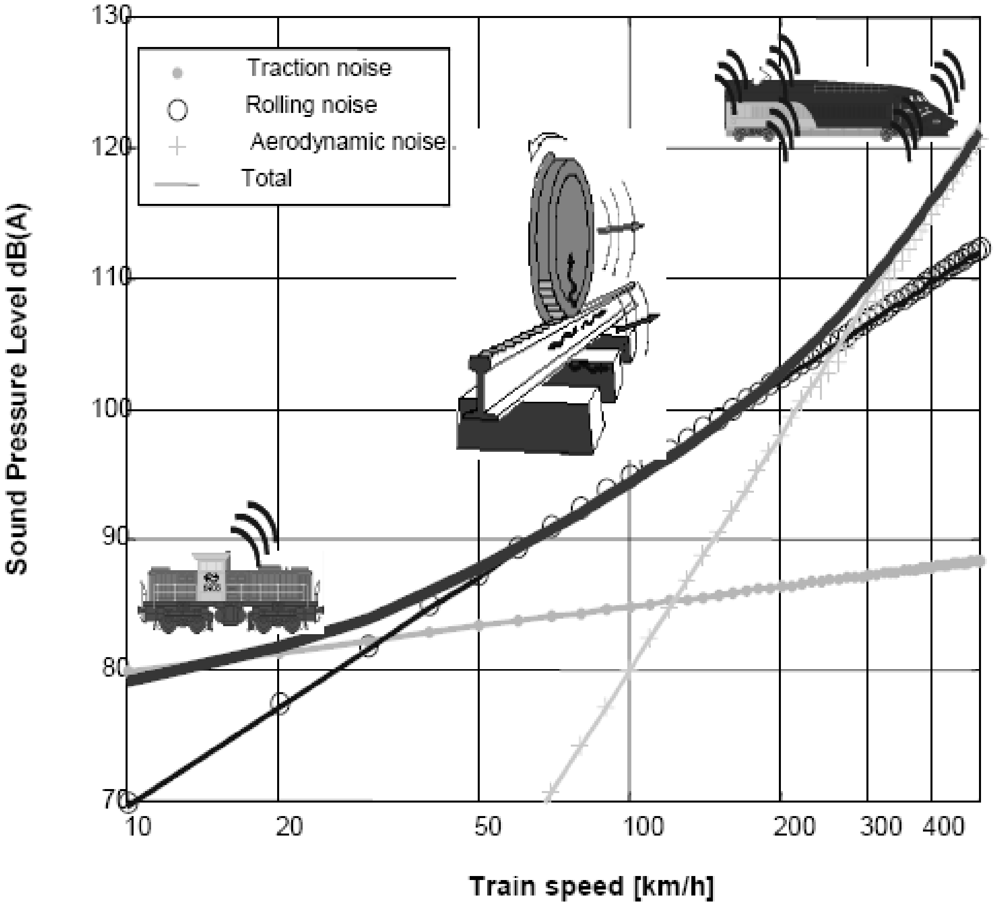

Figure 2: Rail exterior sound sources and their typical dependence on train speed.
(Hemsworth, 2008)

People living near transport infrastructure are irritated by noise. The number of European citizens disturbed by traffic noise is increasing due to the growing demand for transport. The European Commission has implemented the Directive on Environmental Noise No. 2002/49/EC. In this Directive a noise indicator LDEN was defined for monitoring noise levels during the day, evening, and night. Based on this Directive the noise mapping of major roads, railways and airports was carried out in each Member State.

The graph in the Figure 3 (Rail transport and environment, 2008) shows the percentages of citizens disturbed by air, road, and rail traffic noise during the night.

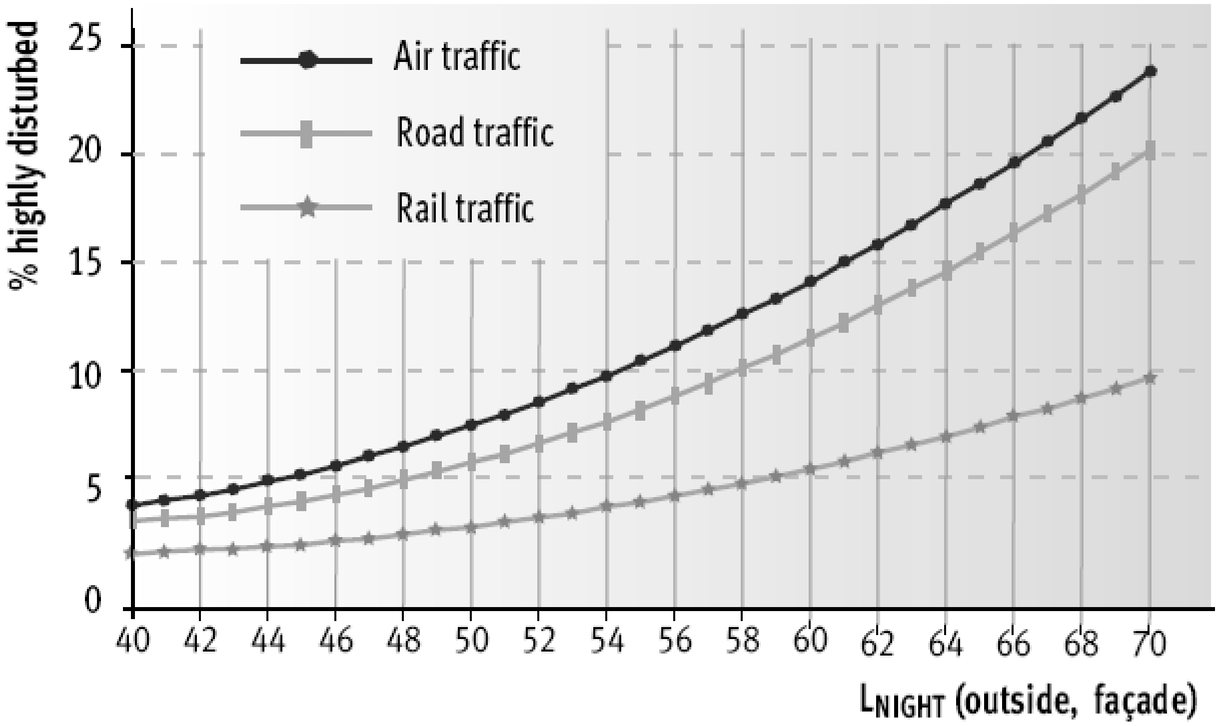

Figure 3: Percentages of citizens disturbed by traffic noise.
(Rail transport and environment, 2008)

3 DIRECTIVES ON INTEROPERABILITY

The term interoperability is defined as the ability of the rail system to allow the safe and uninterrupted movement of trains, which clearly implies the integration of the railway system. The following text shows that first high speed railways were dealt with. The reason for this is that high speed lines are relatively new and still evolving.

The Directive on the interoperability of conventional routes, which faces many problems, the majority of which stem from the standpoint of their historical development, came later. Infrastructure, as well as rolling stock, was designed according to national specifications and there is a large difference between countries that virtually prevents any merger.

The Trans-European railway network can consist only of tracks in which the compatibility between the characteristics of rolling stock, including the boarding systems and the characteristics of railway transport routes, can be guaranteed.

Individual subsystems are related to interoperability, and can be divided into either structural or operating. The structural subsystem mainly includes the infrastructure and vehicles, as well as traffic management, control, and the arrangement of the energy. The operating subsystem consists of maintenance and telematics applications.

Interoperability is the ability of diverse systems to work together. In the rail sector interoperability is a European Commission initiative to promote a single market. There have been several directives adopted by the European Council since 1996 (see the graph in Fig. 4).

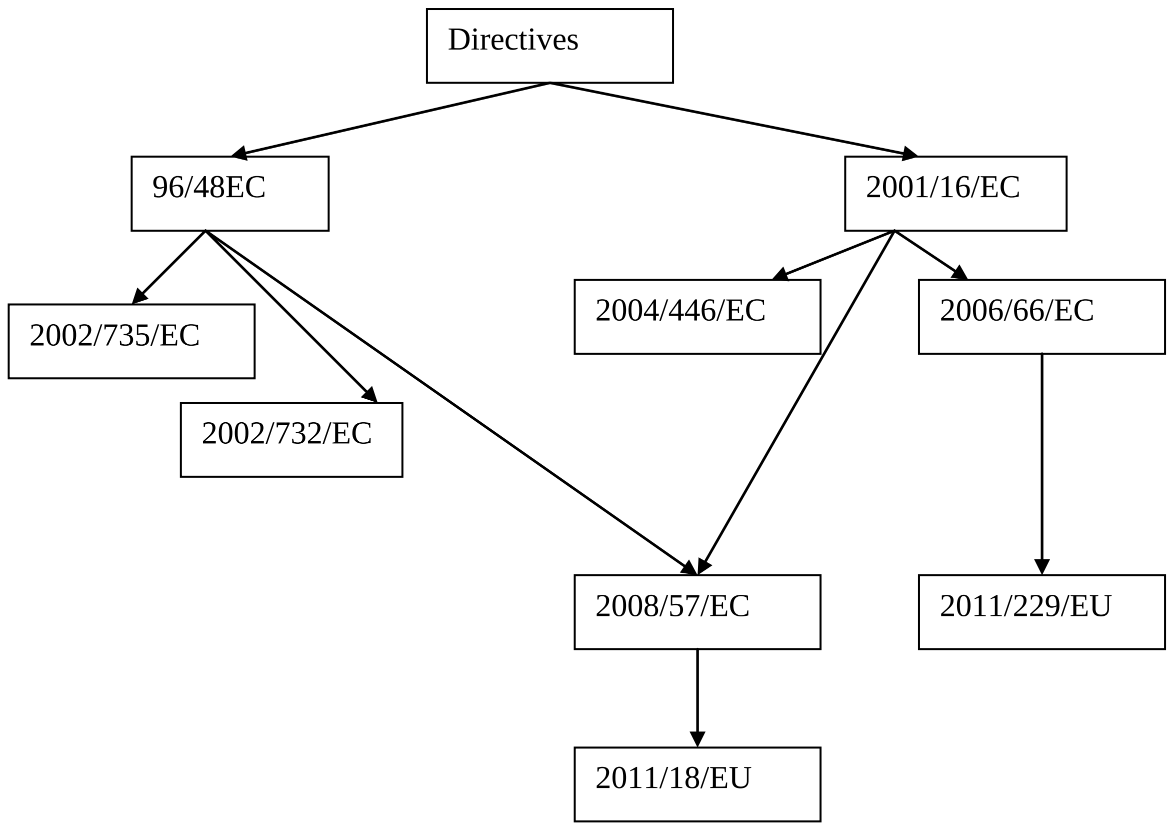

Figure 4: Directives on interoperability according to rolling stock.

The first was the Council Directive on the Interoperability of the Trans-European high-speed rail system – Directive 96/48/EC. This Directive was followed by two Technical Specifications for Interoperability (TSI); Technical Specification for Interoperability, relating to high-speed rolling stock – Commission Decision 2002/735/EC, and Technical Specification for Interoperability, relating to high-speed railway infrastructures - Commission Decision 2002/732/EC.

The second was the Council Directive on the Interoperability of the conventional Trans-European rail system – Directive 2001/16/EC. This Directive came later, due to the diversity of the conventional rail system. There were two Commission Decisions relating to this Directive 2001/16/EC with the Technical Specifications for Interoperability of the conventional Trans-European rail system - Commission Decision 2004/446/EC, specifying the basic parameters of the 'Noise', 'Freight Wagons' and 'Telematic applications for freight', and Commission Decision 2006/66/EC, concerning the technical specification for interoperability relating to the subsystem "rolling stock – noise“.

The TSI document states that the Commission will consider options for the retrofitting of freight wagons for noise reduction with stakeholders and the rail industry. TSIs include noise limits for starting noise, constant speed and stationary vehicles, as well as a track specification.

Both basic Directives on Interoperability (96/48/EC and 2001/16/EC) have evolved over the years and were replaced with a new directive. In July 2008 the European Parliament and Council Directive 2008/57/EC on the interoperability of the rail system came into force, which superseded both of the above Directives.

This directive installs the conditions to be fulfilled to achieve interoperability within the EU rail system at the construction, design, placing into service, upgrading, renewal, operation, and maintenance stages.

The gradual implementation of the interoperability of the rail system is being realized through the harmonisation of technical standards. Therefore this directive covers three main sections. The first covers the essential requirements with regard to safety, human health, environmental protection, reliability, technical compatibility, and operation of the system. The second comprises the technical specification for the interoperability adopted for each subsystem pursuant to this directive. The last part contains the corresponding European specification.

In March 2011, Commission Directive No 2011/18/EU was adopted. This Directive amends Annexes II, V and VI of the European Parliament and Council Directive 2008/57/EC on the interoperability of the rail system within the European Community.

In terms of the rail noise issue 2011/229/EU Commission Decision of 4 April 2011 is important, which concerns the technical specifications for interoperability relating to the “rolling stock - noise” of the trans-European conventional rail system, which voided and replaced the Commission Decision 2006/66/EC.

4 NOISE FROM RAIL TRANSPORT WITHIN DIRECTIVES ON INTEROPERABILITY

Noise of rail transport, particularly freight transport, significantly affects the lives of people around the transport infrastructure and it is therefore necessary to implement measures for its reduction. Measures to reduce noise from railway transport can either be of a technical or legislative basis.

The first group of measures related to railway noise management involved (Transport and Environment, 2011):

- Track type and quality – including wheel-rail rolling contact
- Quieter rolling stock and operation
- Railway structures and noise barriers
- Spatial planning and urban design
- Building insulation

The second group of measures is characterized by the leading role of the European Union. One of the many activities designed to reduce noise levels in the population is to define its limits. The European Union can play a major role in reducing noise through legislation via interoperability directives and also via the creation of technical standards for interoperability (TSI), which include noise standards for equipment and railway infrastructures.

When operating the trans-European conventional rail system must respect existing regulations on noise in accordance with Annex III to Directive 2008/57/EC. For the subsystem rolling stock four chapters in Decision No 2011/229/EU are specified - stationary noise, starting noise, pass-by noise, and driver's cab interior noise. The following Table 1 shows the limit values for the pass-by noise of freight wagons. This table was chosen from Decision No 2011/229/EU, due to freight transport being a significant producer of rail traffic noise.

Table 1: Limiting values $L_{pAeq,Tp}$ for the pass-by noise of freight wagons (2011/229/EU).

Wagons	**LpAeq,Tp in dB**
New wagons with an average number of axles per unit length (apl) up to 0.15 m-1 at 80 km/h	82
Renewed or upgraded wagons according Article 20 of Directive 2008/57/EC with an average number of axles per unit length (apl) up to 0.15 m-1 at 80 km/h	84
New wagons with an average number of axles per unit length (apl) higher than 0.15 m-1 up to 0.275 m-1 at 80 km/h	83
Renewed or upgraded wagons according Article 20 of Directive 2008/57/EC with an average number of axles per unit length (apl) higher than 0.15 m-1 up to 0.275 m-1 at 80 km/h	85
New wagons with an average number of axles per unit length (apl) higher than 0.275 m-1 at 80 km/h	85
Renewed or upgraded wagons according Article 20 of Directive 2008/57/EC with an average number of axles per unit length (apl) higher than 0.275 m-1 at 80 km/h	87

5 CONCLUSION

This article summarizes the development of European Directives on the Interoperability of the Trans-European high-speed rail system and the Interoperability of the conventional Trans-European rail system from 1996 until 2011. The text makes it clear that noise is considered one of the key side effects of transport. The graph in figure 3 shows the time development of Interoperability Directives.

Very important documents in the fight against noise are EU Directive 2000/14/EC - relating to the Harmonized noise emission of machines, products and equipment, and Directive 2002/49/EC on the assessment and management of environmental noise, known by the abbreviation END (Environmental Noise Directive). The aim of this Directive, which the EU Member States adopted as a solution to the acoustic conditions from a long-term strategic perspective, is to provide a uniform procedure for the long-term reduction of noise in the environment.

Other EU documents that are directly related to noise from rail transport were two key Directives - Directive 96/48/EC on the interoperability of the trans-European high-speed railways, and Directive 2001/16/EC on the interoperability of the trans-European conventional rail tracks. These Directives were replaced by the Council Directive 2008/57/EC on the interoperability of the rail system, and in 2011 were amended through Commission Directive 2011/18/EU.

ACKNOWLEDGEMENT

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Political Effect on Major Transport Elements of Budapest after the Transition

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ABSTRACT: The aim of our article is to describe the connection between the Hungarian political environment and the development of the transport system of the Hungarian capital, Budapest, since the beginning of economic transition. The starting point of our research is the beginning of the transitions as from this period the political parties had the chance to make changes in the transport sector in order to build a liveable city. The authors have reviewed the urban transport programs of the parties, which they planned to realize in the case of winning the elections. The authors have dealt only with parties which were present in the Parliament during all parliamentary periods since 1990. The authors have investigated four parameters: length of express roads and the length of the M0 ring road as a parameter of economic growth and development, service levels (length of services, average age of vehicles, number of vehicles) of BKV (a monopoly responsible for urban transport in Budapest) and the length of cycle paths.

KEY WORDS: transport policy, urban mobility, Budapest.

1 INTRODUCTION

The aim of the authors was to investigate the transport policy of the Hungarian capital, Budapest. The starting point of our research is the beginning of the transition of the Hungarian political regime as, from this period on (after having been formed) the political parties had the chance to express their views on the topic. The authors have reviewed the plans regarding transport incorporated into the electoral programs of the parties, which they wished to realize in the case of winning the elections.

The authors have only dealt with parties which were present in the Parliament in all parliamentary periods since 1990, i.e., the beginning of financial transition. These were – in order of governance – the Hungarian Democratic Forum (MDF), the Hungarian Socialist Party (MSZP), the Alliance of Free Democrats (SZDSZ), and the Alliance of Young Democrats (Fidesz). The aim was to review the electoral programs and also the programs of the governments if they contained something in relation to transportation in Budapest.

The authors wanted to compare the main elements of the programs and, following that, with the help of quantitative data to compare the programs with the realized changes. (The authors always counted the years of elections up to the final governmental period.) A 20-year long evolution of four significant factors influencing the transport in Budapest has been charted: the expansion of the motorway-network – increasing the traffic of the capital, the construction of the M0 ring-road – decreasing the traffic in the capital, the number and the mean age of the vehicles of Budapest Transport Limited (BKV, the public transport company of Budapest) – increasing the attractiveness of public transport, and the length of the capital's bicycle track – decreasing passenger transport within the inner city.

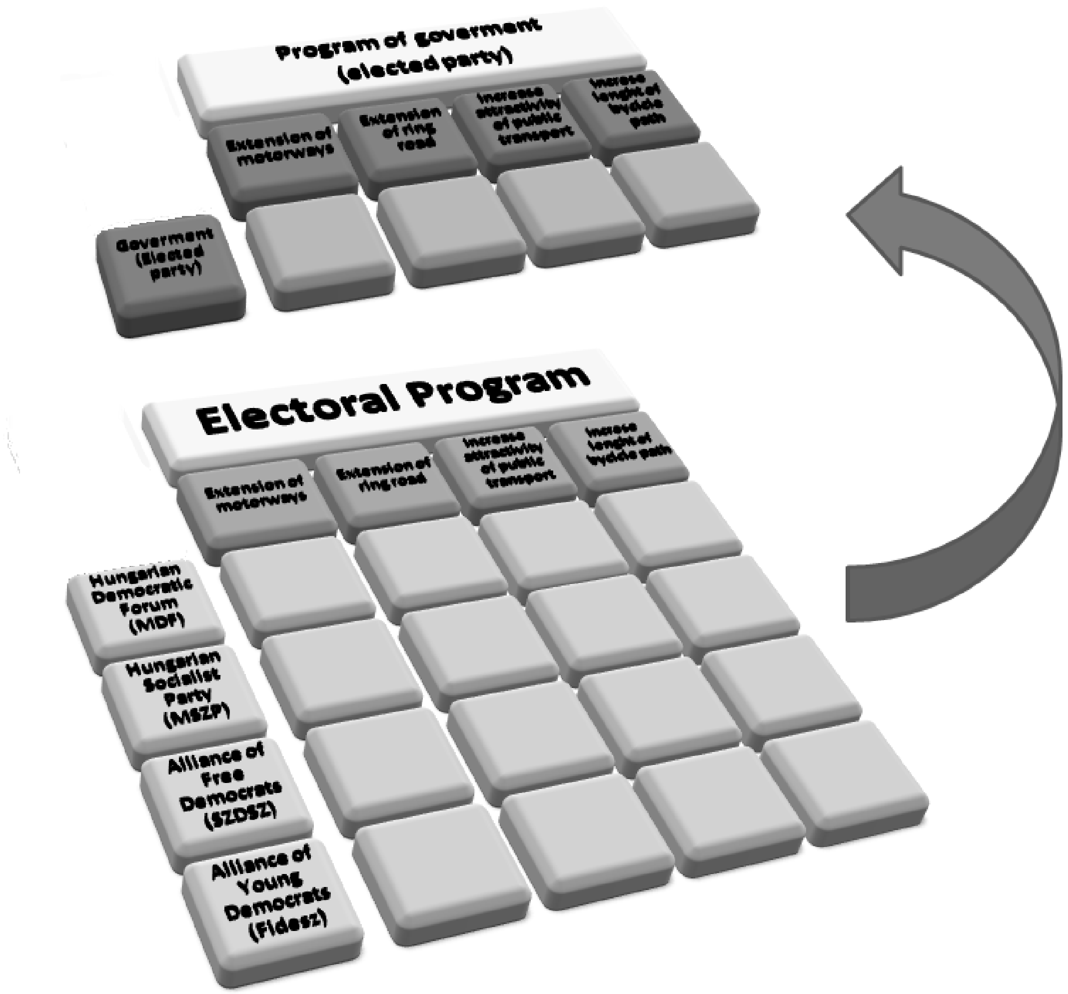

Figure 1: Area of investigation.
(Source: own research)

The European Union realizes its responsibility and opportunities: "*urban mobility policies need to be based on an approach which is as integrated as possible, combining the most appropriate responses to each individual problem: technological innovation, the development of clean, safe, and intelligent transport systems, economics incentives, and amendments to legislation*" (Green Paper, 2007).

2 MOTORWAY-NETWORK

Why do we need to handle the motorway-network and the M0 ring-road in Hungary if the subject of the paper is urban mobility? The question can be answered easily we can find a big challenge in the background. "*Congestion in towns and cities is one of the main problems […]. It is often located on urban ring roads and affects the capacity of the Trans-European Transport Network (TEN-T)*" (Green Paper, 2007). It is also true for Budapest that the congestion damages the state's and the European Union's economic interests. TEN-T is the European transport network created from the member states' own networks.

In 1990 the MDF wanted to increase the speed of motorway construction. Beside this, it would have liked to see the radial network transformed into a ringed network (Program of the Hungarian Democratic Forum, 1989). The Fidesz found that either: the central role of Budapest should be decreased (Program assumed by the II. congress of Fidesz, 1989). The MSZP did not have a written program for this period. The SZDSZ had one but we could not find anything in it in connection with transport. In 1990 the MDF won the elections bu there were two other parties in the coalition government. In their program of governance (Program of the national regeneration, 1990) they emphasized the program of motorway construction which aimed to help the country develop organically. The motorways are one of the most important connections to Europe. The network increased 10.2% in 1994 (always compared to the last year (Hungarian statistical yearbook 2000)). In 1994 none of the parties mentioned the motorways in their electoral programs. But after the elections in one of the main elements of the MSZP-SZDSZ coalition government's program (Program of the Government of the Republic of Hungary 1994-1998, 1994) the government intended to finish the construction of the motorways. The network increased by 10.6% in 1996, 3.6% in 1997 and 16.9% in 1998 (always compared to the last year (Hungarian statistical yearbook 2000)).

The European Commission welcomed the new parts of the M3 and M5 motorways in its Regular Report on Hungary's progress towards accession (Regular Report from the Commission on Hungary's progress towards accession, 1998). In 1998 only the MSZP dealt with the question of the motorways: it said that Hungary needed motorways that reach the country's borders, and needed them developed in a ringed network (Puch, Soós, 1998). The other three parties did not mention anything in relation to this topic. We can read in the Fidesz-MDF coalitional government's program that they wanted to do everything to increase the speed of motorway construction (Governmental program for the civil Hungary, 1998). In 2000 (Regular Report from the Commission on Hungary's progress towards Accession, 2000) and 2001 the Regular Report on Hungary's progress towards Accession (Regular Report on Hungary's progress towards Accession, 2001), the European Commission notes that even though no new parts were constructed the Hungarian government promised to change that trend and Hungary takes into consideration the aims and priorities of the TEN-T network.

In 1999 and 2002, the motorway network increased by 7.1% and 11.7% (compared to the last year (Hungarian statistical yearbook 2007)). The situation in 2002 was quite similar to that of 8 years before: only the new government's (a MSZP-SZDSZ coalition for the second time) program contained something about motorways: they wanted to finish the first section and continue M3 and M5 as a strategic aim (The history of the M0 ring-road, 2010). In 2004 a new prime minister was elected by the parliament who came with a new governance program; this, however, unfortunately did not cover the motorways. Nevertheless the length of the network increased the most in this period: 4.5% in 2003, 7.5% in 2004, 12.0% in 2005 and 20.4% in 2006 (always compared to the last year (Hungarian statistical yearbook 2007)).

In 2006 we find a new situation: not just the electoral but also the governance programs lack intentions relating to motorways. The last governmental period ended in 2010. The length of the network increased by 7.2% percent in 2007, 7.3% in 2008, 0.4% in 2009 and 15.4% in 2010 (always compared to the last year), so the total length of the Hungarian motorway network was 1314 kms in 2010. The results reached in each governmental period can be easily compared with the help of Figure 2.

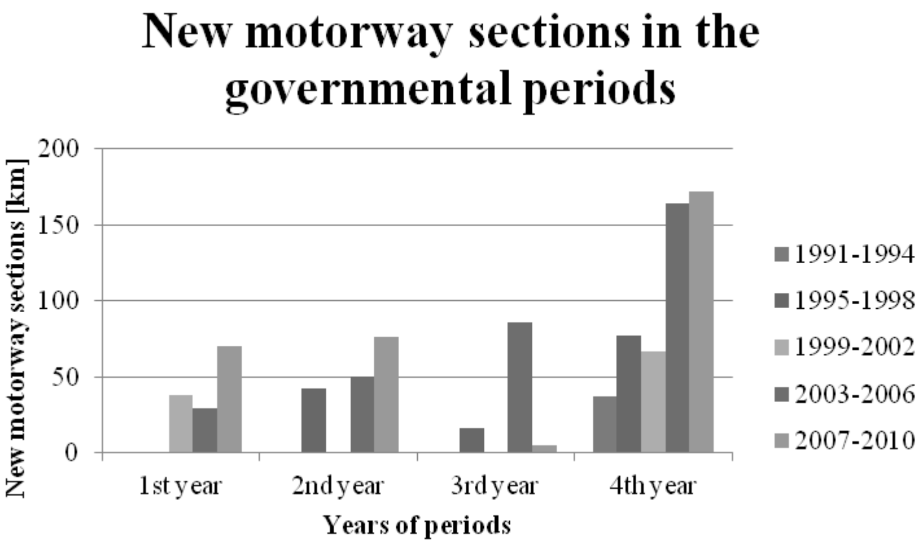

Figure 2: The expansion of the Hungarian motorway-network 1990-2010.
(Source: own research)

3 THE M0 RING-ROAD

The construction of the M0 ring-road was started in 1987. The first 6-km-long section was ready in 1988, but the first longer section could only be used from 1990 (The history of the M0 ring-road, 2010). The M0 is only mentioned by the Fidesz where they say the construction of it is necessary (Program assumed by the II. congress of Fidesz, 1989). The other three parties' and the government's program does not cover the ring-road.

In 1993 the new prime minister in his government's program (Governmental program in the terms of continuance, stability, and development, 1993) promises to finish its construction. Following that a 15-km-long section became ready in 1994 (The history of the M0 ring-road, 2010). In the next eight years, from 1994 to 2002 nobody dealt with the question, irrespective of whether the parties prepared for the elections, or were in governmental or oppositionist status. Nevertheless, 6 kms were constructed in 1999 (Motorways of Hungary, 2010).

In 2002, the coalition of Fidesz and the MDF tried to keep their governmental position. Before the elections they promised to complete the M0 ring-road's northern, eastern and southern sectors and to build the northern bridge (The future has begun: electoral program of Fidesz Hungarian Civil Party – MDF, 2002). The MSZP also mentioned the M0, but not in their electoral program, just in a professional transport booklet (Professional debate documents on the change of the welfare system, 2001): the transit traffic and crowdedness of Budapest must be decreased by building the M0 ring-road, and after that by transforming it into a motorway. As it was pointed out earlier, the M0 was mentioned as a strategic aim by the MSZP-SZDSZ coalition in 2002 (Act now and for everybody 2002-2006, 2002), but only a 12-km-long section was constructed in 2005 (Motorways of Hungary, 2010).

In 2006, the Fidesz (Go, Hungary! Program of the active nation, 2006) and the MSZP (Safety, justice, courage, 2006) both promised the construction of the whole M0, and we can find it in the MSZP-SZDSZ coalition's program as well (New Hungary. Freedom and solidarity, 2006-2010). In the last period it has not been finished (and it will not be ready for the time of the next elections in 2014), but the longest newest section has been operational since 2008.

Recently, we can speak about the lack of the western section, but on the other hand we can see 80 kms is ready (The history of the M0 ring-road, 2010) (Figure 3.).

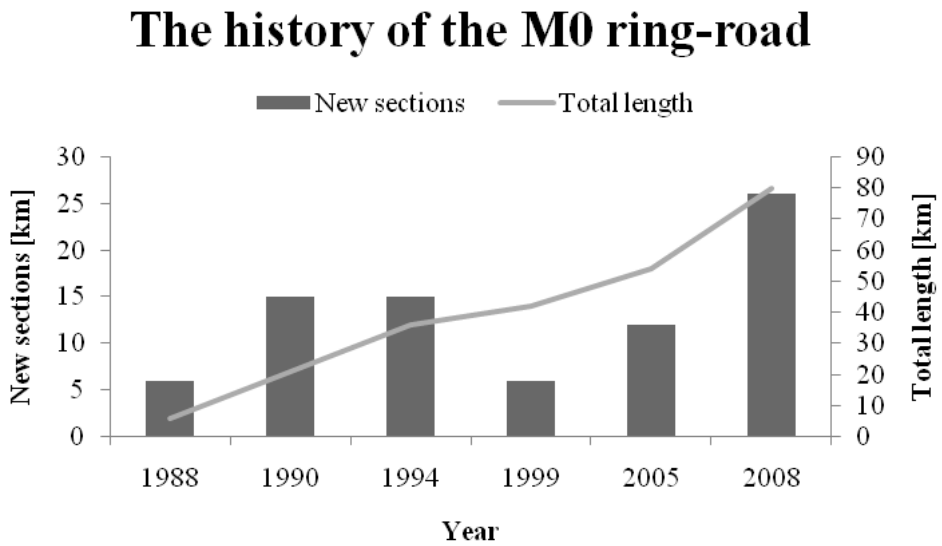

Figure 3: The history of the M0 ring-road
(Source: own research)

4 THE NUMBER AND THE MEAN AGE OF THE BKV'S VEHICLE FLEET

In 1990 in the MDF's (Program of the Hungarian Democratic Forum, 1989) and Fidesz's electoral program (Program assumed by the II. congress of Fidesz, 1989) we can read about the advocacy of public transport instead of individual transport modes. They also wanted buses, which pollute the environment less. On the top of this, the program of the government (Program of the national regeneration, 1990) said that many of the vehicles must be changed. In this period 423 buses, 3 trolleys and 10 metro wagons arrived at the company (Yearly reports of the BKV).

In 1994 none of the parties' programs contained anything about public transport; even the new MSZP-SZDSZ government's program omitted it. Nevertheless, 163 buses and 13 trolleys arrived at the company during this period (Yearly reports of the BKV*)*. Only the buses' mean age decreased in 1995.

In 1998 only the MDF (Safety for every day!, 1998) promised something for public transport, namely supporting the purchasing of buses which pollute the environment less. We can read in the Fidesz-MDF coalitional government's program (Governmental program for the civil Hungary, 1998) about developing public transport (buying modern buses). In this period, 115 buses, 15 trolleys and 10 metro wagons were new in the company.

In 2001 BKV bought 76 used trams from Hannover (Yearly reports of the BKV). In spite of having new vehicles the mean age did not decrease significantly. In 2002 again, only the new government's program (Act now and for everybody 2002-2006, 2002) contained a few words about developing and modernizing the stock of vehicles (but after electing a new prime minister in 2004 his new program did not contain it). In this period 150 Volvo buses, 15 trolleys and the first 26 Siemens Combino trams began serving the people in Budapest (Yearly reports of the BKV).

In 2006 only the SZDSZ (Freedom, competition, solidarity 2006-2010) said that if public transport is to be kept alluring, it was necessary to improve its quality. After the elections, these thoughts also permeated the government's program (New Hungary. Freedom and solidarity, 2006-2010). The purchase of new vehicles occurred in 2007 and 2009. 14 new Siemens Combino and 10 trolleys (Yearly reports of the BKV) arrived before the company then bought 32 used Belgian buses (Directly from Belgium, 2009). The first Alstom Metropolis metro wagons began their test runs. Of course, many of the oldest vehicles have been junked. We can say that more than 30% of the vehicles have been changed up to 2008 (compared to the numbers for the year 1990). The mean number of the BKV's vehicles was 2869 in 2008. Fig. 4a and 4b shows the change in the numbers and the mean ages of the BKV fleet.

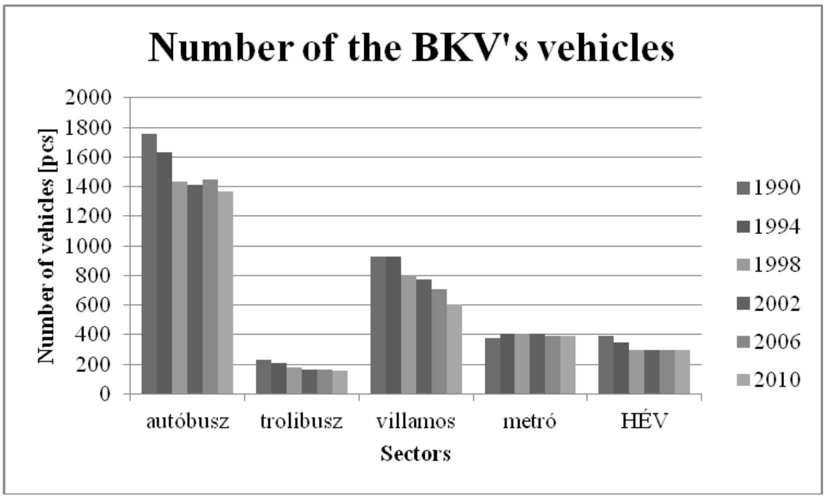

Figure 4a: Number of BKV's vehicles.
(Source: own research)

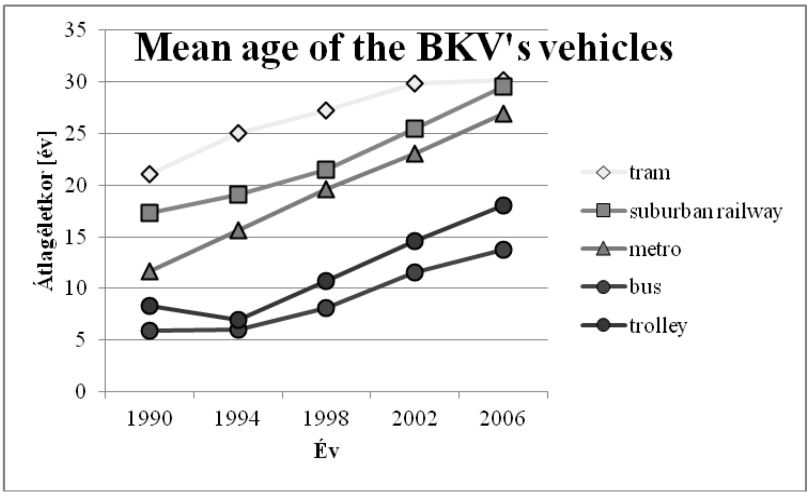

Figure 4b: Mean age of BKV's vehicles.
(Source: own research)

5 BICYCLE TRACK NETWORK

The use of bicycles is becoming more popular from year to year. "*In the view of stakeholders, improving the perceived safety and security depends on a number of measures in the urban environment. High quality infrastructure, including good pavements for pedestrians and cyclists, can make a difference*" (Green Paper, 2007). In 1990 only the Fidesz (Program assumed by the II. congress of Fidesz, 1989) handled the question. As they stated in their electoral program, they supported bicycle traffic and they were even ready to support it at the expense of car drivers in the inner parts of cities. After the elections one had to wait for the second government's program (in 1993) (Governmental program in terms of continuance, stability and development, 1993), as it had been promised to build several kms of bicycle track. The data known from this period is that 282 million HUF had been spent on building the track (The capital is committed for the development of the bicycle transport, 2009).

In 1994 none of the electoral and government's programs mentioned the bicycle roads. In spite of this 429 million HUF was spent on constructing new sections. In 1998 the total length of the bicycle tracks reached 100 kms (The capital is committed for the development of the bicycle transport, 2009).

In 1998 the MDF (Safety for every day!, 1998) campaigned with supporting cyclists and pedestrians; the Fidesz (Freedom and welfare, 1998) campaigned with the promise of constructing new tracks. The MSZP's and SZDSZ's programs did not tackle the question. Although the Fidesz and the MDF got the chance to govern in the next four years, unfortunately their program did not contain this task. In spite of this 684 million HUF was spent on constructing new tracks and the total length of the roads almost reached 140 kms (The capital is committed for the development of the bicycle transport, 2009).

In 2002 only the MSZP dealt with the question but none of the electoral and governments' programs mentioned it. As for MSZP, the professional transport booklet (Professional debate documents on the change of the welfare system, 2001) contained it. They point out the necessity of integrating these roads into a network. In this period 215 million HUF was spent on constructing new bicycle roads, and, with this, the total length of the network reached 170 kms (The capital is committed for the development of bicycle transport, 2009).

In 2006 again only one party mentioned the question and this time it was the SZDSZ (Freedom, competition, solidarity 2006-2010, 2006). They stated that the network needed development. In spite of mentioning this, the government's program did not contain these goals. In 2007 and 2008 17 kms were constructed so that the total length of the network reached 187 kms (The capital is committed for the development of the bicycle transport, 2009). The expansion of the network since 1990 is shown in Figure 5. However, we unfortunately do not have recent data from the last years.

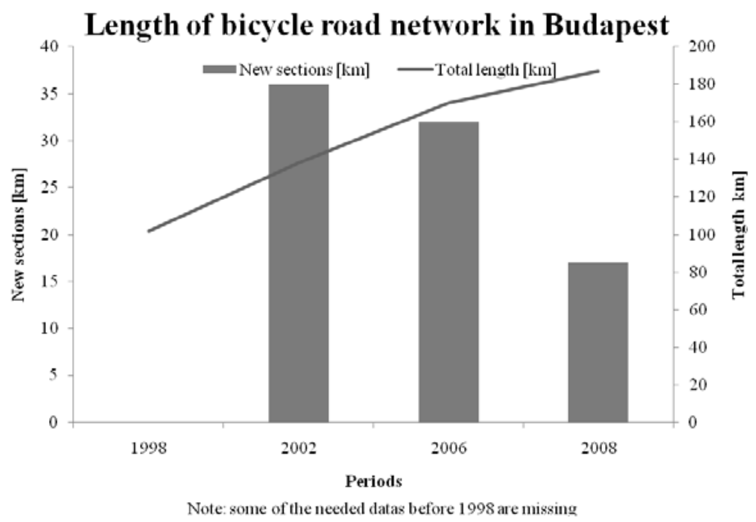

Figure 5: The broadening of the bicycle road network 1998–2008.
(Source: own research)

6 SUMMARY

It can be stated about the Hungarian motorway network that it is four times longer than it was in 1990. The M0 ring-road is still not complete, but has become 80 kms long recently. This development was indispensable in order to decrease the transit traffic and crowdedness of the capital. The development of the expressway system was shelved in time, caused by an unwanted increase in costs.

The network of the BKV expanded during these twenty years, but this result is mainly due to the bus network. Although we have to admit that still too many old polluting vehicles are running on the roads of Budapest, we can regularly come across modernized buses and trams. One third of the vehicles were changed during the twenty years and many of the oldest ones were decommissioned. Still more investment is necessary because most of the financial resources are devoted to the new metro line. All the other public transport modes are suffering from the lack of financial backing. Finally, we can acknowledge that the bicycle road network has been increasing dynamically, although not as a system, but as separated sections have been built. The development of Budapest's transport system has not stopped in these years, as, of course, it could not stop.

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Selected Problems of Electric Vehicle Dynamics

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ABSTRACT: This paper deals with the analysis of unsprung masses of electric vehicles with the in-wheel drive, from a dynamics point of view. The system safety and comfort are evaluated. This paper also brings together the modern possibilities of use of the propulsive components of the in-wheel drive – the basic types of electronic commutated motors. The technical note presents the ROMO vehicle – a project of DLR (German Aerospace Center).

KEY WORDS: Electric Vehicles, Suspensions, Vehicle Dynamics, In-wheel drive.

1 INTRODUCTION

The "motor in wheel" design concept of electrical vehicles brings essential advantages in the possibility of independent traction and the steering control of each wheel, a compact design and easy production technology. The drawback is the increasing unsprung mass of wheel assembly, which is even relatively higher when considering the contemporary effort of car body mass reduction leading to lower energy consumption, reduction of the batteries weight impact and enabling a further operating range. The relatively high unsprung mass decreases the handling quality of the vehicle. The general and basic requirement of vehicle active safety is that the tyre must be in good and continuous contact with the road surface, even on a rough and uneven track. The length of the rebound depends on the unsprung mass, therefore a wheel with additional equipment suffers with a worse tyre-road contact (or this contact is lost on some obstacles). This leads to a reduction of braking efficiency on an uneven or poor road surface, and to the limited handling capabilities, especially cornering characteristics and behavior.

The design of the in-wheel motor is described as well and the mass of the parts is taken into the consideration. There are several possibilities how to realize this type of motor. The most widespread are the motors with electronic commutation, due not only to their suitable construction design, but also their control as well.

The conclusion is devoted to the successful design of a DLR vehicle ROMO, which significantly inspires the electrical vehicles design ways.

2 INFLUENCE OF THE HIGHER UNSPRUNG MASS DUE TO THE MOTOR INSTALLED IN THE WHEEL ASSEMBLY

The design strategy of the electric vehicle based on electric motors assembled in the wheel centre, the so-called in-wheel drive (or wheel hub drive), brings new challenges in vehicle traction control, handling, and maneuverability due to the independent wheel steering. Moreover, the vehicle concept with drives in the wheels gives new design possibilities and therefore innovative car body structural conditions, including the utilization of non-conventional materials in car body design, can be developed. Both passive and active safety receives the new dimensions and solutions.

The negative feature of motor installation in the wheel assembly part is the higher unsprung mass m to the sprung mass M (Figure 1) when compared to a conventional power train of road vehicles, and, consequently, the lower level of handling and ride safety (braking and line changing capability) (Kovanda et al., 1997). The usual design demands and generally accepted condition is to reduce the unsprung mass to achieve a tyre-road contact as stable as possible. There are some examples of relatively complicated design solutions to minimize the wheel assembly mass (break system and assembly are fixed to the car body), the utilization of light materials at suspension mechanism, etc.

Therefore, the mass of the electric motor added to the wheel assembly systems brings serious problems from a ride dynamics point of view. This understanding gives us the two-mass (quarter car) model (see Figure 1).

The Eigen frequency of an unsprung mass is:

$$\Omega = \sqrt{\frac{c + c_\tau}{m}}$$

The influence of a higher mass m is a lower eigen frequency and, consequently, a lower vertical acceleration of the wheel on the uneven surface. This is quite a good feature from a vibration propagation and comfort point of view.

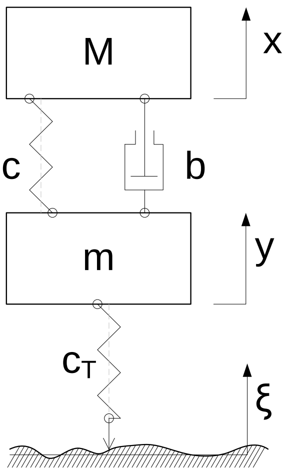

Figure 1: Two-mass vehicle suspension model. (Kovanda et al., 1997)

The drawback is significant declination of the handling quality due to the loss of the tyre – road contact on the road irregularities. The higher unsprung mass leads to the smaller critical unevenness high on the road ξ, where the tyre loses contact with the road surface due to jumping away.

The solution is in a higher damper coefficient b. This can be seen in Figure 2, especially from the upper part (after the break point) for higher frequencies. The more efficient dampers improve the handling quality, but “harder” dampers bring lower levels of passenger ride comfort.

Possibly the electric motors built in the wheel center member will activate higher attention to the active control and feed-back systems utilization in the field of wheel suspension systems and vertical dynamics.

The controllable dampers (semi-active suspension) and/or springs (fully active suspension) can solve the conflict between safety and comfort, which is amplified by additional unsprung mass. Even the simple on-off damper with a basic sky-hook control strategy can bring significant improvements to the vehicle’s characteristics.

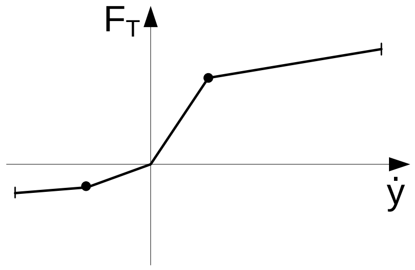

Figure 2: Damper characteristics: velocity $\dot{y}$ vs. force FT.
(Kovanda et al., 1997)

3 IN-WHEEL MOTORS

As said before, the heart of the discussed electric vehicle is the electric drive in the wheel’s centre. An electric drive generally consists of an electric motor, a power converter, a part of an electric apparatus, and a necessary drive system. It is no different in the case of an in-wheel drive. The drive is composed of a kind of electric motor, power electronics converters, and control electronics. It can be said that the whole mass is really concentrated in the middle of wheel. Not only is the electric drive there, but also the mechanical parts, such as wheel bearings, a brake, a suspensions interface, or heat sink, account for the mass in the middle of wheel.

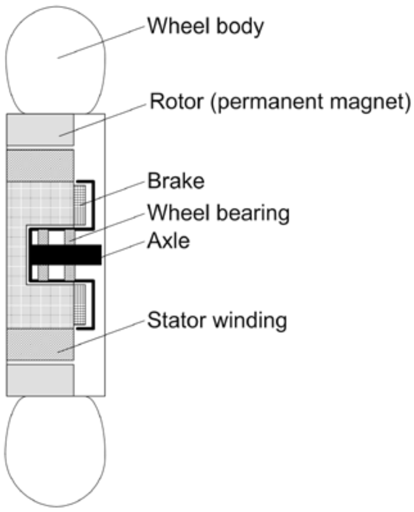

Figure 3: Cross-section of a common in-wheel motor.

Several types of electric machines can be used as a motor. However, the three-phase synchronous motor has been shown to be a very good option (Li & Qian, 2011). The unusualness of a synchronous motor construction, unlike a classical construction, is a rotor from permanent magnets surrounding the fixed stator, with the stator winding in the middle (see Figure 3). The rotor is a fixed component of the wheel's body.

This type of a motor is known as an electronically commutated (EC) motor. EC motors are of two types: brush-less DC (BLDC) motor and permanent magnet synchronous motor (PMSM). The accumulator or the batteries are the main power sources in an electric vehicle. These sources are sources of DC voltage, but the synchronous motor is the AC machine. It is only the question of terminology. An electronic commutator is a semiconductor converter which produces the required AC supply of EC motor waveforms from the DC source (Figure 4). Both the BLCD motor and the PMSM are machines of almost the same construction (Lis, 2011). The only one difference between them is the distribution of a magnetic field course.

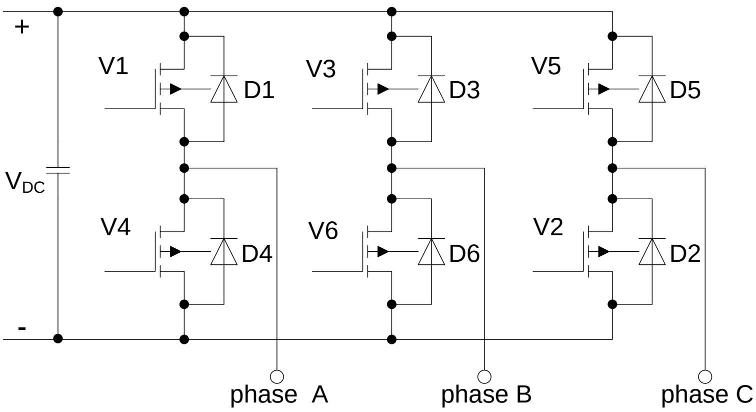

Figure 4: Power scheme of the electronic commutator.

The back electromotive force (analogue of the induce voltage in winding machines) of the BLDC motor is a trapezoidal shaped, the PMSM has physically adapted a stator winding for a sinusoidal shape of the magnetic field. The reason for the use of the trapezoidal shaped magnetic field lies in the easy control strategy of the drive (Lis, 2011).

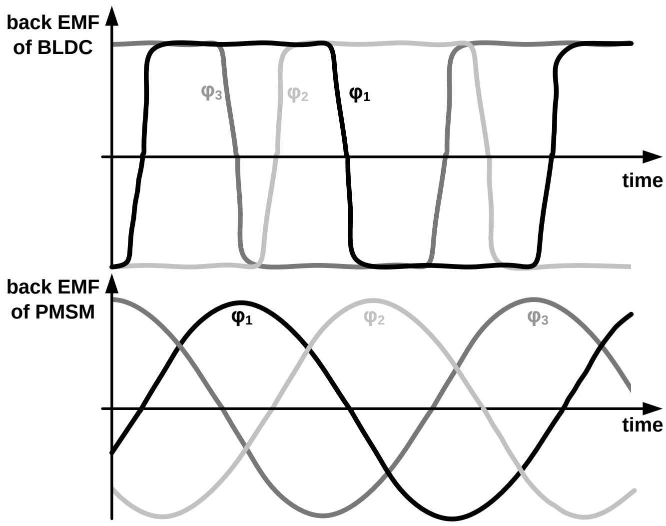

Figure 5: Back EMF of BLDC and PMSM.

The converter for the supply of the BLDC motor can be driven only by a simple pulse-width modulation (PWM). Every moment only two from three phases are fed by rectangle voltage pulses in a star connection of a stator winding. Of course, it is possible to drive the BLDC motor also harmoniously. The back EMF however approximates a sinusoidal waveform, but not the same as the PMSM. Its main disadvantage is the non-uniformity of the wheel rotation. Therefore, the more sophisticated vehicles are equipped with the PMSM as the main drive. The BLDC motors are used as auxiliary drives.

The sinusoidal shaped magnetic field of the PMSM rapidly improves the uniformity of the wheel rotation compared with the trapezoidal shaped field. Both waveforms of the magnetic field are shown in Figure 5. However, the control algorithm of PMSM is significantly more difficult. It is necessary to generate with the help of a converter not only one sinusoidal wave, but waves for all three phases. The converter generates the three-phase voltage with a frequency which is proportionate to the wheel rotation (Glinka, 2008).

4 CONCLUSION

The in-wheel drive system brings a new technical solution to vehicle design. The high level of maneuverability is the main advantage in city traffic. The high mass of the wheel assembly and the reduced mass of car's body can bring with it problems on uneven roads, especially in the tire – road contact quality. The solution for this conflict can be found in the active systems utilization, as described in the technical note.

5 TECHNICAL NOTE

The research organization DLR (German Aerospace Center - www.dlr.de) developed a unique electric car based on sophisticated design principles (Schaub et al., 2011, Brembeck et al., 2010). The suspension and steering systems design, as well as the control concept utilized the wide experience of the research team in the field of robotics and active dynamic systems. The team of prof. Dr.-Ing. Gerd Hirzinger, director of the DLR – Institute of Robotics and Mechatronics, designed the robotic electric vehicle ROMO.

Figure 6: DLR concept ROMO.

The philosophy of the ROMO concept is an intelligent system with a central control system consisting of four active units (wheel assembly) integrating the functionality of the drive-train, brake, steering, spring and damper. The main advantage is excellent maneuverability enabled by four in-wheel drives and four independently actuated wheel steerings. To command such an overactuated vehicle the integrated vehicle dynamics control is supported by a camera system.

DLR has selected the solution of the in-wheel motor with an inner rotor and an outer stator from aluminium. As the main motors used, PMSM are fitted in 17’’ wheels. With their nominal rate of 1 000 rpm the vehicle can reach a maximal velocity of 100 km/h and deliver a peak torque of 160 Nm. Analyses of DLR have shown that it is sufficient to cool the motor at this power rate using air. Thanks to air-cooling, the weight of a vehicle is lower than when compared to other ways of cooling (Brembeck et al., 2010).

The steer actuator is also together with the main drive in the center of a wheel. It is a 370 W harmoniously controlled BLDC motor (Brembeck et al., 2010).

The car body is made from non-conventional materials (carbon fiber structure) for mass reduction. The inspiration from aircraft design at DLR is evident (Figure 6). The ROMO vehicle is a demonstration of a successful interdisciplinary project between electro-mobility, robotics, and car body design.

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Energetics, Security and the Sustainable Development of Cities

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ABSTRACT: Life in cities and its quality increasingly depends on transport means and on the energy used for their propulsion. A much discussed reason for the substitution of classical energy sources is also energy security; a second reason is the decreasing energetic returnability of oil. This paper draws attention to some aspects connected with accessibility to passenger transport in the city system. It is emphasized that the solution of the above-mentioned problems takes into consideration many factors, not only those from the field of transportation. These factors influence one another; therefore it is necessary to find ways how to harmonize these factors for achieving the sustainable development of the city system. The sustainable city development is conditioned by the bearable development of the transport system so that access to various transport modes is ensured for all city inhabitants, and so the sustainable mobility of the city's inhabitants is ensured.

KEY WORDS: Energetics, security, sustainable development, city, urban transport, quality.

1 INTRODUCTION

Transportation has, during the whole of history, been a basic driver of the form of human society. It determined not only the location of towns, but also their internal form, and, last but not least, it was the basic element of economic development as the inevitable presumption of the barter of goods. Its role in the 21st century will not change and the question is rather in which form we will use transport in the future. The trend of the last few decades (especially the acceleration of car transportation) has shown that one has to solve above all the problems of the transport in cities, to combat the lack of space and also additionally the problem of the energy resource for transport (or the substitution of oil by another resource) whatever the reasons will be - environmental ones (lowering of transport emissions), strategic ones (connected above all with the oil and gas supply security from countries where they are attained), or additional ones (above all the discussed exhaustion of oil during the next 50-100 years).

The environmental impacts of car transport by far concern the cities where the majority people live. Quality urban mass transport and a solution of the propulsion of transport means, in the sense of lower emissions, can thus significantly contribute to the sustainable development of cities and to a higher quality of life.

Urban transport was still developing at the break of the 19th and 20th century in an idyllic way – the urban mass transport had been gradually rising without the serious competition which the individual car transport would become as late as in the course of the 20th century. European cities have been fumbling with the lack of space, as their centres were not designed for this type of transport. Besides that it brought a big underflow of revenue for the urban transport companies, as shown in Figure 1.

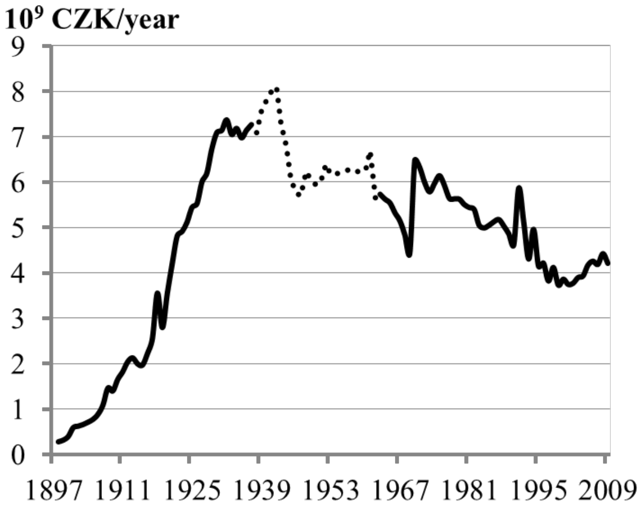

Figure 1: Revenues of the Prague urban transport in the 20th century (real price level 2009, gross estimation 1938-1962).
(Baroch, 2011)

The graph shows that (excepting the period 1938-1962) the revenue maximum of the Prague urban transport was attained in the thirties of the 20th century, and the revenue has been decreasing during its second half - except for two price rises in 1970 and 1991.

2 CITY, SYSTEM, TRANSPORT

The city as a system consists of a number of elements, among which linkages and interactions increase. These elements can be described as follows:

- Activities: products, services, trade, education, culture, travel, and other activities
- Infrastructure: office buildings, residential housing, schools, plants, shops, transport infrastructure-roads, railways, airports, etc.
- Land used for various purposes
- Mobile elements: people, goods, transport means
- Political and social structure: plans, goals, decisions

On the one hand in the city system population activities have been functioning and on another one the economic structure has been created. The action of both these two structures is given by several levels: the national, regional, and urban one. Both structures then create the urban space, where the human activities take place; from the viewpoint of the population these activities can be classified into four categories or factors: work opportunities, production activity and services, the infrastructure use, and the land use. These activities are connected by communication (in a general conception of communication) and the transport system is an implicit component.

To this static conception has to be added the dynamic approach, as the development of the city system has been changing over time both quantitatively and qualitatively.

The dynamics of changes can relate to central parts of a city when decentralization of activities from this region happens as a consequence of technology changes and criterion economic choice. Outside of this region new residential and office objects appear, new infrastructure springs up. Technical development in the field of transport and communication technologies functions on the city system through two effects. The first one creates a more homogenous land use than in the case of the centralization of activities in the city centre. The second effect makes cities more attractive than small town systems through the building of big commercial, financial, and office centres in big cities.

The economic base has moved from the city centre to suburban regions and this decentralization phenomenon is supported mainly by the development of the car industry and the higher incomes of the inhabitants. Easier access to cars helps then to the higher mobility of the labour force, and so to the further growth of suburban regions. The transport and telecommunication network amplifies the decentralization in the city space.

The big growth in car numbers allows, on the one hand, the high mobility of city inhabitants, but on other hand it strongly influences the city environment and quality of life. In spite of the many approaches trying to harmonize the individual city transport the problems still remain. The question of making public transport more attractive has still failed to be answered by transport strategy and planning. The proposals for public transport support have been eliminated on the other hand by the construction of additional parking areas (land use management), especially through the construction of underground garages in the city centre. This is what one of the approaches to the city system factor integration is connected with. It is city development with respect to the linkage of public transport to the commercial, administrative, and industrial areas, and the harmonization with individual car transport. Taking into account the economic and social factors as the two substantial factors of the city system, the transport supply then constitutes the necessary support of the function of these elements. But, at the same time, transport influences its neighbourhood, and so it is necessary to control other elements of the city system: land use and transport linkage.

City activities are usually considered to be main processes integrating communication and thus also transport services. In this context one needs to choose another approach to the concept of a product or a service, so that economic and social interests are better fulfilled. This problem is dealt with through marketing. The customer chooses the products and services according to their utility. The marketing should thus supply not only the product, but also the whole chain of services, so that the complete supply of the final utility delivery originates including the transport service.

3 CITY DEVELOPMENT AND TRANSPORT SYSTEM

The transport demand has the character of a derived demand. This also holds true for the urban transport system. People use their time for the realization of many activities. All these activities have their own particular transport demand functions. These activities are realized within the broad city area. There are commercial, industrial, and residential areas, as well as hospitals, schools, theatres, libraries, and sport areas. But the city area must also take into account the transport activities: the construction of the transport infrastructure as an essential factor of the transport service supply.

However, various people’s activities take place at various places at various times of the day. The quality of one man’s satisfaction in the city is finally measured by the opportunities to take part in various activities. The result is the demand for city transport. The logical consequence is that the demand is determined by the number of people living in the city area. The wish or need of these people is to get to the specific place at the specific time. This is why transport rush hours result at particular moments of the day. These peaks are influenced by the beginnings and ends of work, and with the connected travel to commercial and industrial centres and residential areas. A tension between the supply and demand rises at various times of day.

Various transport modes covering the transport demand create a pressure on the transport infrastructure in various ways. Individual car transport affects the city transport system more vigorously than, for example, bus transport. In addition, various transport means differently influence their neighbourhood. They emit into the environment gaseous exhausts and noise emissions, they cause transport accidents and create traffic congestion. If a city should healthily develop, it must keep a reasonable balance between the demands for the further expansion of activities and for further land use. The consequence of city development is then also the demand for transport development, and therefore the demand for the land use, because the extent and quality of transport supply depends on this development.

Consequently the transport problems are only one of the factors of city development. If public transport can compete with car transport its quality must still be highlighted during the next decades. The service quality criteria include availability, accessibility, information, travel time, customer service, comfort, safety, security, and the environmental impact. If individual car transport is step by step distanced from the city centres by suitable measures (e.g., economic measures, like road tolls), quality public transport must substitute it. In addition to this is the connection with the quest for financial sources, as higher quality also means higher additional costs (e.g., many transport companies converted to low floor busses at the turn of the 20^{th} and 21^{th} century, but they bring with them higher investment and operational costs).

We summarize the basic factors influencing the city development and the transport system:

- Economic activities of a city are usually concentrated in central areas, although many activities often move to suburbs. It always causes congestion as a result of people’s demands for travelling to the same place (whether in central or suburban regions) at the same time.
- The deterioration of the environment can be caused by the above-mentioned effects, called externalities, but also by other impacts independent of the transport.
- The accessibility and mobility are the basic conditions of the functioning of a city. The accessibility is to be understood as the possibility of access of the inhabitants to a number of activities through the access to transport. Mobility is to be understood as the ability for movement in the city through the transport system. Mobility can have many limitations: delays caused by congestion, high transport costs, or low revenue of a transport company.
- The losses from public transport can be described partly by the demands for high investment into the transport infrastructure, partly by operation sources. The tariffs often do not cover these high costs and the losses of transport companies therefore rise. The competition of individual car transport and daytime dependent demand increase these losses.
- Social considerations are connected with the question of accessibility and mobility for all city inhabitants.
- The consumption of fuels and energy creates an essential factor of the functioning of the transport system. Nowadays, oil and natural gas supplies are a serious problem, since these commodities have been becoming scarce re-sources. That is why the pressure has been being put on the more effective transport systems with lower energy consumption of transport means all over the world.

4 MOBILITY AND ITS CONTROL

The changes taking place in the post-industrial society towards an information and knowledge society also pressure changes to the city system. These changes can be described by the following linkages and interactions from the viewpoint of the transport system:

- Mobility control with the use of marketing strategies with a complex concept of system elements.
- Implementation of the transport control strategy and area planning with accessibility to transport services.
- Harmonization of the freedom of motion (door-to-door) with the decision-making about infrastructure investments, with the project, real estate, and development decisions, and with the decisions of transport companies ensuring the public transport.
- New marketing approach to commercial, industrial, and administration activities.
- City system management and social responsibility.

The integration of these factors can be ensured through a managerial approach using the control of these factors towards the creation of a network of activities that will ensure a competitive and effective pressure on the support of the city system development with respect not only to economic goals, but also to the social and environmental responsibility.

The concern is in fact the connection or linkage of a city inhabitant or consumer partly with the suppliers of production values (big industrial, commercial, and administration centres), and partly with the suppliers of access routes (operators, deliverers, and other cooperating systems). Control is made so that mainly the strategic and the planning activity leads not only to the local development of fragments with good accessibility, but also that the accessibility to all localities and city system parts is ensured.

5 ENERGY AND TRANSPORT

World economics has been facing an increase in crude oil and nature gas prices. Nature gas's price increase is usually rather delayed. The primary resources of energy, both oil and nature gas, represent an essential raw material not only for energy and transport systems, but they also have the large part in the development of other industrial branches. In contrast to the previous crises, we have come across certain opinions and predictions about the termination of the cheap oil and natural gas period. World economics should forget their low prices. It might seem that higher prices signal a lack of oil and natural gas, although this could be false information. The contribution points out numerous factors influencing the price of important energy resources. The combined impact of the supply and demand is in question, as well as the problem of the exhaustion of the above-mentioned resources and the competitiveness of alternative resources, geological and geographical conditions, reliability of the supplies, and, last but not least, the political, social, and terrorist aspects.

Energy remains an important production factor of economic growth. Energy resources must be safe and reliable, environment-friendly, and will have to be sufficient for the future. None of the contemporary energy resources is close to any of these conditions.

The demand depends on the following factors: changes in industrial structure, material changes and substitutions, transport changes, and the development of energy technologies with higher efficiency. These factors can influence the end energy usage in the sectors as shown: Civil Engineering (40%), Industry (30%), and Transport (30%). It is supposed that the structure will tend to a higher rate of energy used in transport and still remains based on the combustion of fossil fuels. Primary energy resources are crucial for the next decision process. The condition of sustainable development based on a steady growth of the exploitation of primary resources leads to limited consumption in countries with higher income (energy conservation). Changes in energy production and transformation at a higher efficiency should raise the lower energy consumption in developing countries.

We face two problems: the environmental impacts of fossil fuels, and the possibility to replace these energy sources. Displacing fossil fuels from their current dominate position leads to a discussion of alternative sources based on renewable energy. If we take into account that current fossil fuels cover about 90% of the total world supply, we can have doubts about any long-term solution. Simply restriction of the use of fossil fuels will generate adequate incentives to develop and use new energy sources, and will create abundant new energy technologies that do not rely on fossil fuels. But it is apparently belief. There are reasons to doubt that changing the relation of prices and thereby the incentives to use fossil fuels will bring forth alternative forms of energy in the amounts required.

The energy crises confirmed that the interest in alternative possibilities always rises when these crises last longer. It was also verified in 1973, when the interest in the use of alternative sources both in energetics and in transportation began to rise. The competitive ability of alternative sources results from the comparison with fossil (non-renewable) energy resources:

- Renewable resources can still not compete with fossil fuels, as their price is lower with respect to their present surplus. But in many cases the possibility of competition exists.
- The use of actual fossil sources has its limitations. One of these limitations is the fear of contribution to emissions towards the greenhouse effect.
- Non-renewable sources are a concentrated form of solar energy.
- In renewable sources solar energy is dispersed.

There exist the following groups of factors that can influence the use of natural gas and oil:

- Essential growth of prices.
- Growth of changes in the environment that can be influenced by the use of fossil fuels as the dominant primary energy source.
- Energetics problem: how to substitute these fossil fuels so that a relatively sufficient amount of these fuels is substituted by other fuels with a corresponding provision for energetic needs.
- Safety risks and crisis situations.

The production of the greenhouse effect with an essential contribution of carbon dioxide and factors influencing the carbon dioxide emissions can be expressed in the macroeconomic equation:

$$CO_2 = POP \,.\, h.\, en.\, eCO_2$$

where CO_2 = amount of carbon dioxide emissions; POP = population; h = GDP per capita; en = energy intensity of the economic system; eCO_2 = amount of carbon dioxide on the unit of energy carrier (carbon intensity).

It follows from the equation, that emissions grow with the population growth, with the economic growth, with the high energy set out of the economy and with the high portion of fuels with a high carbon content for the produced energy unit. The high content of carbon leads to high carbon dioxide emissions. The population and economic growth will be followed by the growth of emissions.

The emissions can be reduced by:
- reducing energy intensity
- reducing carbon intensity

To decrease the carbon intensity means to move from fossil fuels to fuels with low or no carbon content.

6 CONCLUSION

Transport in the 21st century will have to solve the serious problem of energy sources. It is of course a problem as old as mankind itself, that was solved (evidently only temporarily) in the period of the peak industrial revolution, when oil became the ideal product for the propulsion of transport means.

Oil found its fatal use as a motor propulsion source at the turn of the 19th and 20th century. A natural source became an economic one; mankind has known it for long, nevertheless only the technological development caused by the industrial revolution made it possible to use oil in a truly substantial way. In this context we can ask whether we are not also in the same situation in looking for a new energy source for the future, maybe only yet next unknown technologies make it possible to use as fuel in transportation that what we have before eyes now, but we cannot see it.

From the many alternatives to oil no one is sufficiently competitive when we apply to such alternative fuels the four basic requirements – i.e., the technological, energetic, environmental and economic comparability with conventional fuels. From a technology viewpoint not only are the transport means themselves necessary, but also the construction of the infrastructure of the filling stations (in the case of electric cars the charging ones). The next problem of fuels is their energetic characteristics –the rate of the energy gained and used. This rate is most favourable for the energetic commodities which have the basic advantage of offering a large amount of energy in a low volume of commodity. In the case of oil this rate was best during the beginning of its use, but it has gradually been decreasing with the worsening of its extraction conditions.

Electricity, meanwhile, puts itself forward as a possible substitution for the classical fuels in transportation. It is nothing new; the use of it as a means of transport propulsion was already debated at the beginning of the 20th century. Today this idea has returned, also with respect to a technological shift above all in the development of accumulators. Today’s accumulators can be recharged to 60% in 15 minutes again (on the other hand it decreases the battery lifespan). Of course, the problem with electric cars remains the distance that they can travel after one charging and other running features. That is why their use is expected first in cities, where there are enough possibilities for charging (overnight or at the workplace). As for energy sources, not only classical ones can be used, but also local ones, e.g., wind or solar energy.

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ITS and Electronic Toll Systems

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ABSTRACT: In the paper the Czech toll system and its future are presented. The paper describes also the ITS solutions for use of the possibilities of electronic toll system for reducing congestion on the highway network of the Czech Republic, as well as solutions of differentiated toll tariffs and their impact on changes of fleet towards ecological vehicles with EURO V and higher engines. In conclusion, it is presented a new certified methodology used to determine the toll tariffs in terms of EU directives.

KEY WORDS: toll system, traffic regulation, congestions.

1 INTRODUCTION

In response to the situation in the surrounding states, fees started to be charged for the road network in the Czech Republic in 1995 and highway vignettes were introduced for that purpose. The motive was to secure further funds for the development of mainly the highway network and for the prospective solution concerning related applications.

Even when in 2007 an electronic toll system involving output-related payments based on the distance covered within the network of highways, expressways and selected sections of the roads of the 1st class was introduced in the Czech Republic for vehicles in the weight category of 12 t and more, the highway vignettes remained for the other categories of vehicles.

With regard to the interoperability of the toll systems within the EU, there is a European Commission Decision of 6 October 2009 on the definition of the European Electronic Toll Service and its technical elements (EETS). According to this decision, the EETS system should be implemented in the EU within 3 years from the year 2009.

2 IMPLEMENTATION OF AN ELECTRONIC TOLL SYSTEM (ETS) IN THE CZECH REPUBLIC

In the period of the years 2002 and 2003 and other years, various studies and experts's statements were prepared and works and opinions of experts from the Ministry of Transport of the Czech Republic and other institutions and scientific centres were presented on electronic toll.

Already at the time when the task was defined, it was emphasized that the money collected from the output-related payment system as well as the money collected from the time system (vignettes) would be used solely for reconstruction of, repairs to and construction of the road network, including its development, also connected with the issues of traffic regulation, information, telematics and safety. The preparation of the implementation of the toll system was also based on the European Directives – particularly 1999/62/EC and 2006/38/EC, and the 2004/52/EC directive (interoperability) was also continued to apply to the Czech Republic.

The history of the implementation and changes in the Electronic Toll System (ETS) in the Czech Republic is in Table 1.

Table 1: The history of changes in the Electronic Toll System in the Czech Republic.
(Source: Ministry of Transport of the Czech Republic)

Date	Change
1.4.2006	Closure of the tender for the toll system – contract signature.
1.1.2007	Introduction of tolls on motorways and expressways.
1.1.2008	Introduction of tolls on selected sections of 1st class roads.
1.1.2010	Extension of toll on vehicles with weight higher than 3.5 tons.
1.2.2010	Introduction of increase in toll rates by 50% on Friday from 3pm to 9pm included, which was compensated by decrease in rates during other hours of the day and week. The result was a reduction of traffic on tolled communications by about 11% in the period of increased toll rates.
1.1.2011	Increase in toll rates by 19% and introduction of an independent emissions group EURO V, which is not subject to an increase in toll rates. Reduction of increased toll rates at selected Friday hours to 40% as compensation for carriers.
1.9.2011	Introduction of individual reduced toll rates for buses. Toll rates for buses are differentiated only by the emission class and are not increased on Friday.
1.1.2012	Estimated increase in toll rates by approximately 25%, except buses and vehicle class EURO V and higher.

Organisation of the construction and operation management of ETC in the Czech Republic:
Investor/Buyer: Ministry of Transport of the Czech Republic (MD ČR)
Operator: Road and Motorway Directorate of the Czech Republic (ŘSD ČR)
Mobile Enforcement: General Directorate of Customs (GŘC ČR)
Project Manager: Consortium of Deloitte Czech Republic and Bovis Lend Lease, a.s.
General Contractor and operator of services of ETC: Kapsch Consortium. Kapsch has provided the complete operation services for the Czech Republic since January 2007. The total term of the contract is 10 years.
Auditor: Logica

3 THE RESULTS OF THE OPERATION OF THE TOLL SYSTEM IN THE CZECH REPUBLIC

Table 2 shows the development of the toll road network in the Czech Republic with the prognosis of development until 2017. The same table shows the reality and forecast of the revenues from the toll road network ETS. The revenues from time coupons for vehicles less than 3.5 tons are not included in these calculations. In the Figure 1 there is a map of the charged road network in the Czech Republic in the 2012. In Table 3 there are applicable data of toll tariffs on toll road network of the Czech Republic in 2012.

Table 2: Survey of total toll income and total length of toll roads development.
(Bina et al., 2011)

Exchange rate of 1 EUR = 24,445 – Czech National Bank, 14. 9. 2012

		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total toll income	[mil. CZK]	5 433	6 012	5 431	6 422	7 994	9 571	10 069	10 334	10 606	10 885	11 352
Toll of vehicles above 3,5t	[mil. CZK]	5 433	6 012	5 431	6 422	7 994	9 571	10 069	10 334	10 606	10 885	11 352
Motorways and expressways	[mil. CZK]	5 433	5 700	5 173	6 129	7 659	9 170	9 658	9 912	10 173	10 440	10 896
1st class roads	[mil. CZK]		312	258	293	335	401	411	422	433	445	456
Toll of vehicles bellow 3,5 tons	[mil. CZK]	0	0	0	0	0	0	0	0	0	0	0
Number of distributed OBU		252 628	351 124	398 079	466 796							
Motorways and expressways	[km]	937	993	1 034	1 149	1 368	1 391	1 415	1 440	1 465	1 490	1 516
1st class roads	[km]	0	180	198	196	196	196	196	196	196	196	196
Total lenght of toll roads	[km]	937	1 173	1 232	1 345	1 368	1 391	1 415	1 440	1 465	1 490	1 516

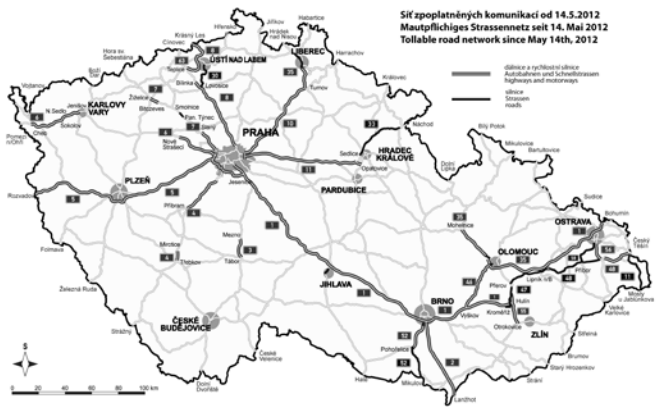

Figure 1: Map of the charged road network in the Czech Republic in 2012.
(Source: Road and Motorway Directorate of the Czech Republic)

Table 3: Toll rates table 2012
(Source: Road and Motorway Directorate of the Czech Republic)

Exchange rate of 1 EUR = 24,445 – Czech National Bank, 14. 9. 2012

Toll Rates for Trucks [CZK/km] in most of weekdays									
	Emission Class EURO 0-II			Emission Class EURO III-IV			Emission Class EURO V+		
2012	Axles								
	2	3	4+	2	3	4+	2	3	4+
Highways	3,34	5,67	8,24	2,61	4,45	6,44	1,67	2,85	4,12
Roads	1,58	2,74	3,92	1,23	2,14	3,06	0,79	1,37	1,96

Toll Rates for Trucks [CZK/km] Friday 15:00 — 21:00									
	Emission Class EURO 0-II			Emission Class EURO III-IV			Emission Class EURO V+		
2012	Axles								
	2	3	4+	2	3	4+	2	3	4+
Highways	4,24	8,10	11,76	3,31	6,35	9,19	2,12	4,06	5,88
Roads	2,00	3,92	5,60	1,56	3,06	4,38	1,—	1,96	2,80

Toll Rates for Buses [CZK/km]			
2012	Emission Class EURO 0-II	Emission Class EURO III-IV	Emission Class EURO V+
Highways Roads	1,38	1,—	0,80

In Figure 2 and 3 behaviour of the traffic volumes in 2011 (July-August), by the type of roads (Figure 2) and by vehicle category (Figure 3) are shown.

As in previous years, 92% of the traffic volume is on highways and expressways. The remaining 8% of the traffic volume is carried out on selected sections of 1st class roads. Traffic volumes are relatively stable, although there was an increase in 2010 owing to the expansion of the range of vehicles that are subject to the toll and also in recent months following the opening of the heavily used ring road around Prague. It is interesting to notice that the monthly traffic volumes are created by around 190 thousand vehicles, even though the number of registered vehicles exceeds 500 thousand.

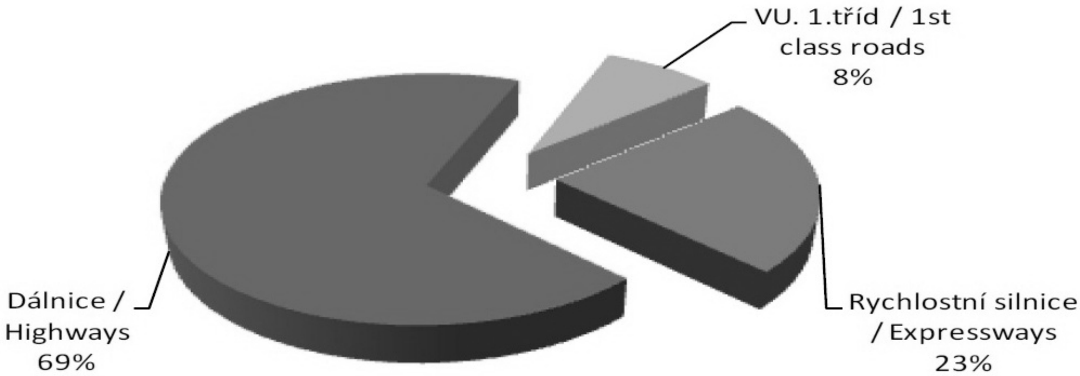

Figure 2: Traffic volume by type of roads (1.-8./2011).
(Source: DWH of the E-toll System/DWH – Data Warehouse of the E-toll System)

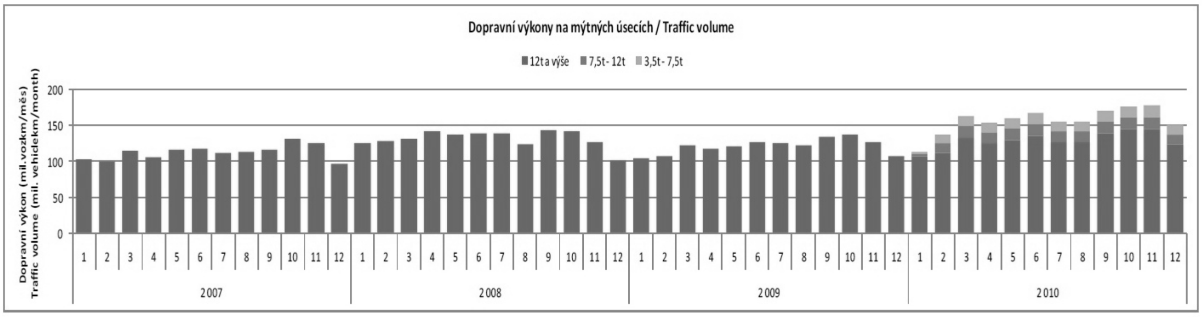

Figure 3: Development of traffic volume in years 2007-2010.
(Source: DWH of the E-toll System)

In the monitored period, the traffic volume of vehicles registered in the toll system was approximately the same as we can see for vehicles weighing over 12 tons on the tolled sections that were put in operation on 1 January 2007. In 2009 a moderate downturn can be seen as a result of the economic cycle, followed by a slow recovery in 2010. Under these assumptions, in period from year 2010 till 2017, weighted average tolls of heavy goods vehicles on motorways, expressways and tolled 1st class roads are always below the maximum weighted average toll (following Figure 4).

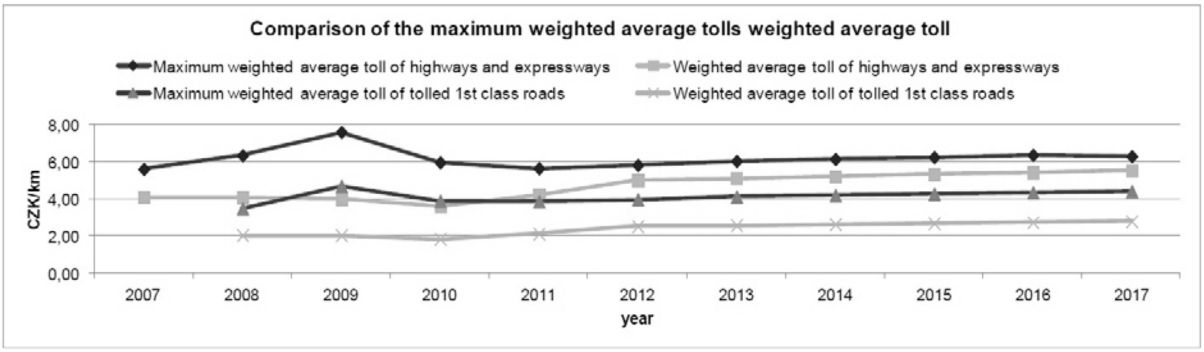

Figure 4: Weighted average tolls of heavy goods vehicles on motorways, expressways and tolled 1st class roads till 2017.
(Bina et al., 2011)
(Exchange rate of 1 EUR = 24,445 – Czech National Bank, 14.9.2012)

4 ANOTHER MAJOR APPLICATION WILL BE INTRODUCTION OF DIFFERENTIATED TOLL IN THE AFTERNOON HOURS ON FRIDAY

Internalisation of the external costs is the main priority of the transport policy of the EU. The basic principle is to charge the vehicles, which have a negative impact on the environment and health and which generate a noise burden on the surroundings of the roads and congestions. One of the works on the topic of charging transport externalities in road transport is the work of the Joint Research Centre – JRC European Commission.

In the Czech Republic, it was necessary to address the situation concerning the restriction of operation of vehicles in the Czech Republic. Section 43 of the Act No. 361/2000 Sb. (Sb. = Collection of Laws) *on the traffic on roads and on changes to some Acts (the Road Traffic Act) defines the scope and the periods of restrictions on the travel of some vehicles. Trucks and special automobiles and special vehicles with the maximum admissible weight exceeding 7,500 kg and trucks and special automobiles and special vehicles with the maximum admissible weight exceeding 3,500 kg with an attached trailer vehicle are prohibited from driving on a highway and a 1st class road:*

- On Sundays and on public holidays as defined in special legislation (hereinafter referred to as the “rest day”) from 13.00 to 22.00.
- On Saturdays in the period from 1 July to 31 August from 7.00 to 13.00.
- On Fridays in the period from 1 July to 31 August from 17.00 to 21.00.

Within the governmental and parliamentary activities and a number of negotiations with road forwarders and their professional organisations, a proposal for higher charges for the Friday trips of vehicles weighing more than 3.5 tons on Friday afternoons was accepted as a measure to reduce congestions on the highway network of the Czech Republic during Friday afternoon hours on an all-year-round basis and on the following conditions:

- The existing legislation restrictions on the vacation traffic remain in effect.
- On Fridays from 15.00 to 21.00, the toll rates are increased by 25 % for vehicles with 2 axles and by 50 % for vehicles with 3, 4 and more axles, on an all-year-round basis. The earlier starting hour for application of increased rates before the period of the legislation restriction (17.00 – 21.00) has been chosen because there is an increased traffic intensity level of passenger cars on Friday afternoons already after 15.00.

Increased Friday rates were launched on 1. 2. 2010 and it was the first measure concerning differentiated rates in the EU with the aim of reducing congestions in the highway network.

In the Figure 5 and 6 the average number of domestic vehicles and foreign vehicles on Fridays in the 4th quarter of 2009 and 2010 on tolled network of the Czech Republic is shown. Number of vehicles in the 4th quarter of 2010 is converted to a comparable level of 2009. From these graphs you can see:

- Decrease of number of vehicles in the time period from 15.00 to 21.00
- The difference in the behaviour of domestic and foreign vehicles

In the comparable period (the 4th quarter of 2010) after the introduction of higher tariffs on Friday according to the previous it lead to decrease of vehicles on the tolled road network in the time period from 15.00 to 21.00:

- 2.8% of domestic vehicles (registered in the Czech Republic)
- 6.4% of foreign vehicles

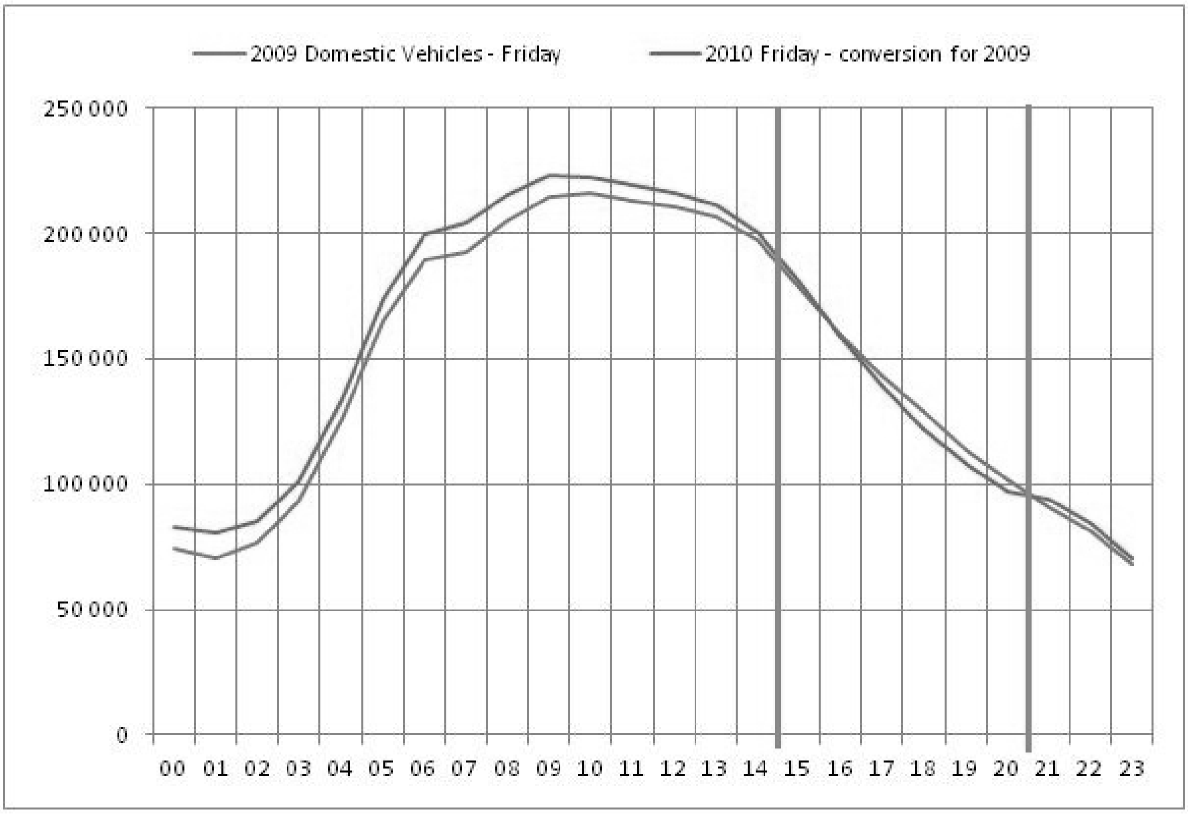

Figure 5: The average number of domestic vehicles on Fridays in the 4th quarter of 2009 and 2010 on tolled network of the Czech Republic.
(Source: DWH of the E-toll System/DWH – Data Warehouse of the E-toll System)

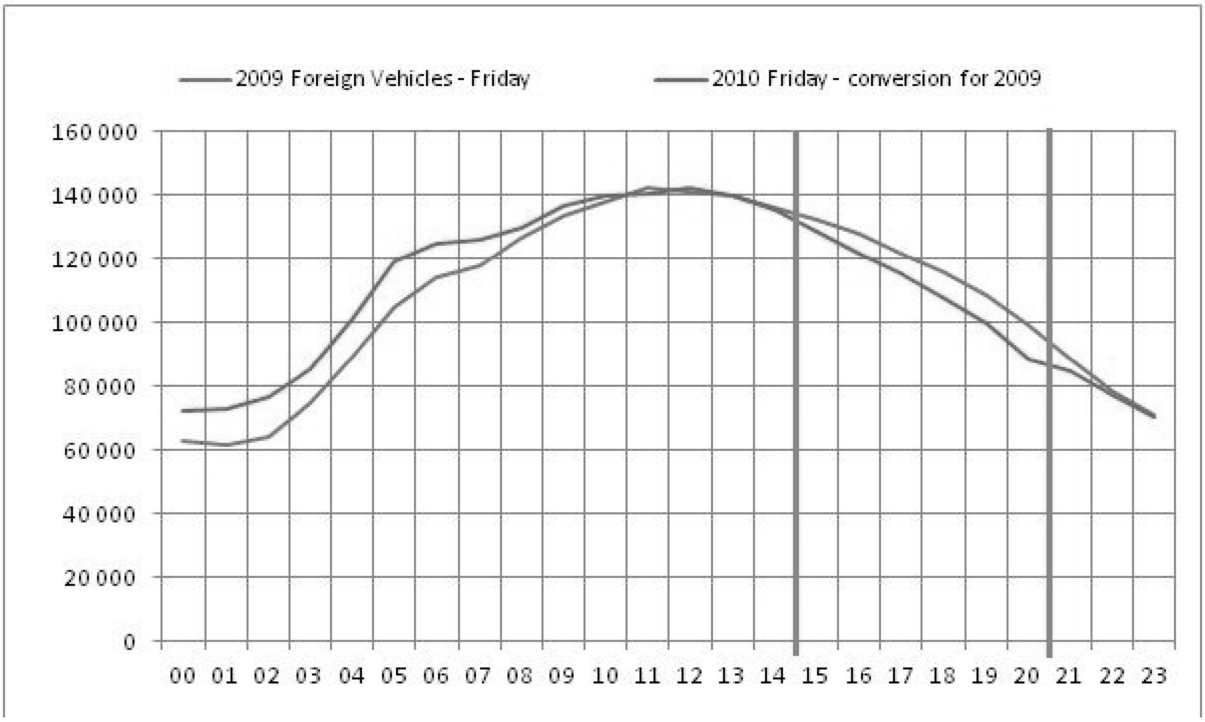

Figure 6: The average number of foreign vehicles on Fridays in the 4th quarter of 2009 and 2010 on tolled network of the Czech Republic.
(Source: DWH of the E-toll System/DWH – Data Warehouse of the E-toll System)

We can say that a significant decrease in trucks and thus a decrease of congestion especially around large agglomerations on the tolled road network in the Czech Republic in Fridays afternoon (15.00 to 21.00) were not found. For domestic vehicles (registered in the Czech Republic) the main reason is probably the end of the work week even the costs are higher. In any case, the whole situation calls for a detailed analysis, because there is (after a very simplified calculation) of approximately CZK 100 million (EUR 4.1 million) an increase in the annual collection of the electronic toll system in the Czech Republic on Friday due to by 50% higher tariffs in the time from 15.00 to 21.00. There is also a recognizable effect on the congestion reduction on the tolled highway network in the country.

5 THE EFFECT OF DIFFERENTIATED TARIFFS OF TOLL SYSTEM ON INCREASING THE NUMBER OF "GREEN VEHICLES"

The effect of differentiated tariffs of toll system in the Czech Republic on increasing the number of "green vehicles" proved in 2011 and in this year, when the toll rates increased on the 1st of January 2012 for the second time by 25 percent. This change did not affect vehicles with EURO V engines. After the increase of toll rates in the Czech Republic by 25 percent, it should bring by calculation through each emission category a result in increased collection of nearly 20 percent. But the reality is only about ten percent. Many carriers have invested in vehicles meeting the EURO V standards. These vehicles have both lower consumption (by 5-10 percent), and also the carriers save on tolls significantly, because the default toll rate is lower than for vehicles meeting only older emission standards and remained at the level of toll tariffs in 2010.

As a basis for the introduction of higher toll tariffs in 2011 and 2012 an analytical report "**Proposal of new toll rates for 2011. Final Report**" from the 10th of December 2010 has been prepared by the Faculty of Transportation Sciences Czech Technical University in Prague and the company Deloitte Advisory s.r.o.

In this report as default assumptions have been defined the following changes in the toll rates made in 2011:

- Introduction of a separate emission class EURO V
- Keeping the EURO III and EURO IV emission classes combined
- Increasing the toll rates applicable to the EURO 0 to EURO IV emission classes by 25%
- Keeping the toll rates applicable to the EURO V emission class at the 2010 level
- Keeping the time differentiation of toll rates during Friday afternoon hours
- The weighted average toll rate shall not exceed the maximum allowable amount derived from the costs of the toll road network and the costs of the toll system.

Subsequently, the average toll rate limit was calculated from the viewpoint of the road costs paid. (Tolls shall be based on the principle of the recovery of infrastructure costs only. Specifically the weighted average tolls shall be related to the construction costs and the costs of operating, maintaining and developing the infrastructure network concerned. The weighted average tolls may also include a return on capital or profit margin based on market conditions - see Article 9 of the Directive - Directive 2006/38/EC) The calculation is based on the following presumptions:

- The constructions costs also took EU subsidies into account, in accordance with Article 9 of the Directive. (Tolls should be based on the principle of recovery of infrastructure costs. In cases where such infrastructures have been co-financed through the general budget of the European Union, the contribution made from Community funds should not be recovered through tolls, unless there are specific provisions in the relevant Community instruments which take into account future toll receipts in establishing the amount of Community co-financing). Whereas the amount of the subsidies allocated towards the construction of roads takes the envisaged toll revenue into account, the authors consider these EU subsidies to be eligible construction costs.
- The operating costs of maintaining and repairing roads were taken into account in full for motorways and expressways, with the appropriate costs for selected tolled sections of class I roads being set proportionally to their length.

Comparison of the newly proposed toll rates with those in surrounding countries

Those rates lower than those of the said option are highlighted in colour in the following mutual comparison of the toll rates with those in surrounding toll systems. These are namely the rates applicable to vehicles having more than three axles – Table 4 and Figure 7.

Table 4: Toll rates with those in surrounding countries (2011).
(Bina et al., 2010)

2011 exchange rate CZK 24,32 /EUR	Toll rates for M and E and vehicles weighing 12 tonnes or more															
	EURO I,II - S1 and S2 exc. PMK				EURO III - S3 exc., S2 with PMK				EURO IV - S4, S3 with PMK				EURO V - S5 and EEV			
Number of axles	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5
Czech Republic	2,83	4,54	6,63	6,63	2,09	3,56	5,15	5,15	2,09	3,56	5,15	5,15	2,09	3,56	5,15	5,15
Slovak Republic	4,69	4,91	5,08	5,01	4,45	4,69	4,84	4,69	4,35	4,60	4,77	4,60	4,35	4,60	4,77	4,60
Germany	6,64	6,64	6,98	6,98	5,11	5,11	5,45	5,45	4,09	4,09	4,43	4,43	3,40	3,40	3,75	3,75
Austria	4,28	5,99	8,99	8,99	4,28	5,99	8,99	8,99	3,75	5,24	7,87	7,87	3,50	4,90	7,35	7,35
Czech Republic	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Slovak Republic	166%	108%	77%	76%	213%	132%	94%	91%	209%	129%	93%	89%	208%	129%	93%	89%
Germany	235%	146%	105%	105%	245%	143%	106%	106%	196%	115%	86%	86%	163%	96%	73%	73%
Austria	152%	132%	136%	136%	205%	168%	175%	175%	179%	147%	153%	153%	168%	138%	143%	143%
Czech Republic	100%	161%	235%	235%	100%	171%	247%	247%	100%	171%	247%	247%	100%	171%	247%	247%
Slovak Republic	100%	105%	108%	107%	100%	105%	109%	105%	100%	106%	109%	106%	100%	106%	109%	106%
Germany	100%	100%	105%	105%	100%	100%	107%	107%	100%	100%	108%	108%	100%	100%	110%	110%
Austria	100%	140%	210%	210%	100%	140%	210%	210%	100%	140%	210%	210%	100%	140%	210%	210%

S1 – S4 – Emission classes according to the Guide for determining the emissions classes of heavy commercial vehicles, valid as at 1 January 2009
PMC – Particulate reduction class – standards for additional adjustments reducing the emissions of vehicles

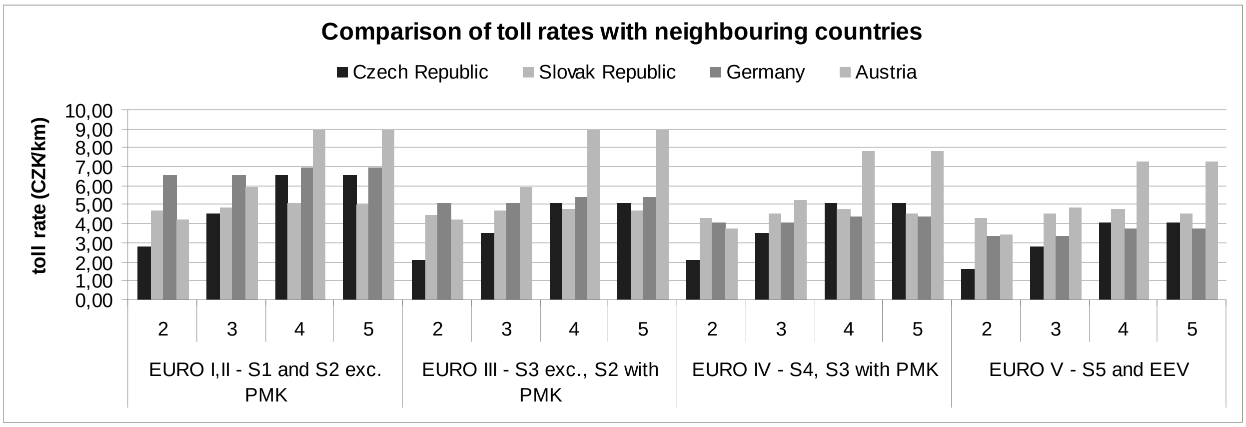

Figure 7: Comparison of toll rates with neighbouring countries (2011).
(Bina et al., 2010)

The same philosophy aimed at supporting green vehicles has also the Federal Republic of Germany, where the amount of toll tariffs strongly supports the introduction of green vehicles with Euro V and higher engines. In Germany dominate in car fleets of transport and logistics companies modern trucks with a weight from 12 tons with low emissions after eight years from the start of toll. In 2005, the share of vehicles with emission class EURO V was less than one percent of overall driving performance, in mid-2012 it was already 77 percent. The share of the trucks mileage of all three emission classes S0, S1, S2 (EURO I, II) -

from 36.5 percent in 2005 to 3.7 percent in 2012 decreased proportionally. The share ofemission class S3 (EURO III) in driving performance have decreased from 64.2 percent to 14.0 percent.

In the Czech Republic during the monitored period the share of vehicles in higher emission classes was gradually increasing. The change in emission ratio of traffic volumes reduces the value of weighted average toll. Keeping the toll rates applicable to the EURO V emission class at the 2010 level meant a significant increase in green vehicles with EURO V engines, which is shown in Figure 8. On the other hand, this measure meant as previously mentioned that after the increase of toll rates in the Czech Republic by 25 percent, it should bring by calculation through each emission category a result in increased collection of nearly 20 percent. But the reality is only about ten percent.

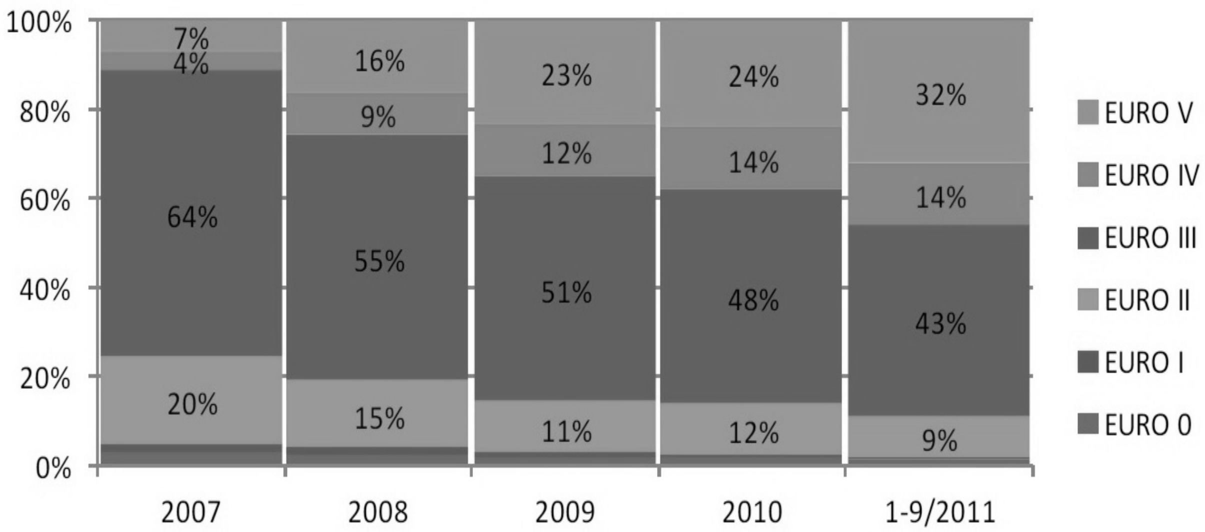

Figure 8: Year over year changes of traffic volume by emission classes of tolled cars in the Czech Republic.
(Source: DWH of the E-toll System)

6 THE NEW METHODOLOGY FOR DETERMINATION OF TOLL TARIFFS

In 2011 an analytical team of the Czech Technical University in Prague, Faculty of Transportation Sciences prepared a report on the new methodology for calculating the maximum weighted toll „Report on the Methodology used to Calculate the Maximum Weighted Average Toll prepared in connection with the Notification of the Czech E-Toll System for the European Commission“. This work was a base for The Methodology of calculating the weighted average toll rates in the Czech Republic, of authors Bína, L., Lehovec, F., Nováková H. (all from the Czech Technical University in Prague, Faculty of Transportation Sciences) Vítek, J., Šnévajs, I. (Deloitte Advisory s.r.o.). This work was in 2012 awarded with the prize of the Rector of the Czech Technical University in Prague in the contest of Czech transport construction, Czech transport technology and Czech transport innovation of the year 2011.

In the following text basic directions and parts of the methodology used to calculate the maximum weighted average toll for vehicles subject to the tolling system operated in the Czech Republic, in accordance with the requirements of Directive 1999/62/EC, as amended by 2006/38/EC are described. The methodology is based on the costs incurred on toll roads as of 1978, i.e. 30 years before the introduction of the tolling system in the Czech Republic in 2007. The maximum weighted average toll was calculated separately for each year (2007–2017). The overall development of selected parameters of the tolling system in the Czech Republic, including the comparison of the reached or planned weighted average toll with the maximum weighted average toll, is presented in the following table.

Table 5: The overall development of selected parameters of the tolling system in the Czech Republic.
(Bina et al., 2011)

Notion	Description
Overall allocated investment costs	Investment (capitalized) costs allocated on heavy goods vehicles above 3,5t incurred in the respective year. Output of the Capex model. Consist of investments in roads and investments in the tolling system, which includes telematics. EU grants allocated in the respective year are deducted. These costs are then allocated equally starting in the year of expenditure and through the depreciation period.
Allocated investment in the road network	Construction costs consist of incurred construction costs and costs of structural repairs, modernization and reconstruction.
Allocated investment in the tolling system	Capitalized investment costs of acquiring the tolling system are included.
Annual share of overall allocated annual costs	Sum of all relevant costs for the relevant year, of which the maximum weighted average toll is calculated in that year.
Annual share of allocated costs of roads	Annual shares of allocated investment costs (interest cost), annual costs of maintenance, and small road repairs.
Annual share of allocated costs of the tolling system and telematics	Operating costs of the tolling system. Also, costs of the tolling system operator, who belongs to a special division of RSD [3]- E-Toll Operator Division (ÚPEM[4]) and activities of inspection bodies of the Czech Customs Administration that provide enforcement are also included.
Total income from toll collection	Sum of collection/plan/regulations of tolls, both actual and expected. Only for heavy goods vehicles.
Toll income of goods vehicles	Toll collection for tolled goods vehicles, ie goods vehicles with a weight above 3,5t, separately for motorways and expressways and for tolled sections of 1st class roads.
Length of network and traffic volume	Contains the basic parameters of the tolled road network, length of tolled sections of roads and traffic volumes, both actual and expected.
Length of tolled network	Lengths of tolled road network.
Traffic volume of heavy goods vehicles on tolled roads	Traffic volumes in millions of vehicle kilometres per year listed according to the type of road of heavy goods vehicles.
Annual change in traffic volume	Annual change in traffic volumes. Influenced by the change in traffic intensity, length of tolled sections of roads and changes in the scope of tolled vehicles.
Toll rates and ratios	Contains the final calculation of maximum weighted average toll and its comparison to actual or expected weighted average toll.
Maximum weighted average toll	**Calculated maximum weighted average toll that should not be exceeded.**
Weighted average toll	**Calculated actual or expected weighted average toll that is counted as a share of the collected toll to traffic volumes.**
Share of tolling income on allocated costs of the network	Percentage share of toll collection on allocated costs of network.
Allocated costs per 1 km of tolled section	Allocated costs per 1 km of tolled section of a road.
Income per 1 km of tolled section	Income from toll collected per 1 km of tolled section of a road.
Share of allocated costs of the tolling system to incomes from the tolling system	Expresses what the share of costs of the tolling system on the total collected toll amount is.

Based on EC Directive 1999/62/EC as amended by 2006/38/EC, Annex III, the maximum weighted average toll shall be calculated from the introduction of the tolling system in the Czech Republic in 2007 to 2011, with an outlook until 2017.

Under these assumptions, in period from year 2010 till 2017, weighted average tolls of heavy goods vehicles on motorways, expressways and tolled 1st class roads are always below the maximum weighted average toll. Comparison of the maximum weighted average tolls to weighted average toll is in the Figure 4.

6.1 Method of determining the costs of road infrastructure

Either the perpetual inventory method (PIM) or the synthetic method can be used to determine the costs of roads. Based on the acquired data series of incurred costs, the PIM method was preferred mainly owing to the possibility of predicting further development of toll rates and owing to the possibility to quickly evaluate the impacts of future investment strategies on the size of toll rates.

- **Synthetic method:** The synthetic method is based on the current amount of assets and depreciation periods of the infrastructure. However, determining the initial value of the assets requires a significant share of qualified estimates, which is why this method was not chosen.
- **Perpetual Inventory Method (PIM):** The PIM method is based on the knowledge of annual costs incurred in the past on the road network. The advantage of this method is that toll rates in the future can be modeled easier, using the trends of the variables monitored.
- **Selection of the method used:** All available information was assessed before the method to calculate the average weighted toll rate was chosen. Historical data for the 1990–2000 periods and a model of price norms from 2008, which were used to determine the value of the road network completed between 1978 and 1989, were available. For the period of 2001 and after, the data is already available in the required structure.

6.2 Historic data until 2010

Data on costs incurred on the construction, maintenance and repairs of motorways, expressways and 1st class roads was obtained from the sources stated below:

- *Information provided by the Ministry of Transport of the Czech Republic*
  - List of EU grants between 2002 and 2010, with outlook for 2013.
- *Information provided by the Road and Motorway Directorate of the Czech Republic (hereinafter "RSD"):*
  - Historical series of costs of construction, maintenance and repairs of roads and motorways for 1990–2000 published on www.rsd.cz;
  - Annual accounts data between the RSD and the State Fund for Transport Infrastructure (SFDI) for 2001–2010. The review of grants is based on RSD accounting, which contains the actual use of costs in individual years;
  - RSD annual reports.
- *Information provided by the Faculty of Transportation Science of the Czech Technical University in Prague ("CTU"):*
  - Price norms of construction of roads 2008 which were prepared for the Ministry of Transport of the Czech Republic
- *Information on the transfer price indexes of construction sites:*
  - Transfer price indexes of construction sites from 1971 to 2009 (Institute of rationalization of the construction industry, URS Prague, 2009).
- *Information on the volume of traffic on motorways and roads obtained from the data warehouse of the tolling system:*

  - Traffic volumes on the network of motorways, expressways and selected sections of 1st class roads for 2007–2010;
  - Planned toll amount for 2007–2010;
  - Division of traffic volumes according to weight categories of vehicles and emissions groups for 2010;
  - Based on the 2010 national transport census, the estimate of the future development of traffic intensity, toll rates and length of toll roads was prepared for the 2011–2017 period.
- *Information on the volume of traffic on 1st class roads obtained from the national transportation census in 2010:*
  - Nationwide transport volumes on 1st class roads.
- *Information on damage caused by vehicles on the state of the roads:*
  - Report by the Transport Research Centre (CDV), „Analýza trendů silniční nákladní dopravy v letech 1995-2003, březen 2005".

6.3 Expected future period from 2011 to 2017

Estimations for the period after 2010 were prepared based on the following data:

- *2011–2013:*
  - SFDI budget for 2011 with outlook for 2012 and 2013, which has been passed by the parliament.
- *2014–2017:*
  - Extrapolation of historical trends in the future development of costs spent on the road infrastructure and planned new toll rates.

Regular annual update of outlook of size of maximum weighted average toll is expected.

6.4 Costs of construction - Motorways and expressways

a) Origin of construction costs
The PIM method requires knowledge of the lifetime of construction costs that were incurred annually and completed at least 30 years before 10 June 2008. Thus, the relevant year is 1978 because the tolling system in the Czech Republic was launched on 1 January 2007 (see Article 3) of Directive 1999/62/EC as amended by 2006/38/EC).

Given the fact that accounting reports were not available for such a long period, the following method was chosen:

- Costs of construction between 1978 and 1989 are derived from the price norms by the CTU, which were prepared to assess the basic costs of construction of the road network. 6% of the costs of the project work were added to the prices. Further evaluation was not conducted. Price norms are prepared at the 2008 price level. Prices of roads between 1978 –1989 were then determined using transfer price indexes of construction objects set by an engineering and consulting organization (URS Prague, see Annex 14.3).
- Construction costs between 1990 and 2000 were taken by RSD from publicly available sources. As the costs were stated in aggregate, they were allocated to motorways, expressways and toll sections of 1st class roads.
- Construction data for the 2001–2010 periods was obtained from billing documents between RSD and SFDI that contain detailed information (in contrast to the previous data).

- Construction costs for 2011–2013 were received from the SFDI budget for 2011, which also contains a mid-term outlook for 2012 and 2013.
- Construction costs for 2014 - 2017 were based on experts estimate.
- Incurred investment costs are allocated equally throughout the 30-year depreciation period.

b) Method of allocating construction costs

Construction costs were distributed and then allocated to toll roads as follows:

- The 1978–1989 construction costs were fully allocated from the price norms on motorways and expressways. Construction costs on 1st class roads were not taken into consideration in this period.
- The 1990–2003 construction costs are stated in aggregate for motorways, expressways and 1st class roads. By the method presented above, the construction costs of 1st class roads were allocated gradually at 36%, using the same average rate as in the case of 2001–2010 construction costs.
- The 2001–2010 construction costs were distributed according to the basis for recognition between RSD and SFDI.
- The 2011–2013 construction costs were allocated based on the SFDI budget, pass.
- Construction costs for 2014 - 2017 were allocated on their previous trends.

6.5 Other costs

In the calculation were included: maintenance costs, investment costs of the tolling system, investment costs of telematics, operating costs of the tolling system and telematics, financial costs, EU grants.

6.6 Calculation of the maximum weighted average toll

This section presents the method of calculating the maximum weighted average toll by Directive (see Article 2, paragraph ba) and Article 7, paragraph 9 of the Directive11). “Directive” means EC Directive/62/EC as amended by 2006/38/EC.

Toll collection cannot exceed the costs incurred on construction and operation of tolled roads and on the construction and operation of the toll and ITS system, including dissolved investment costs for the considered period:

INC <= Ca

INC – Income of toll (CZK) - toll collection in the period,
Ca – Cost allocated to heavy vehicles (CZK) – construction, operating and financial costs allocated on tolled roads and the respective traffic volumes of tolled goods vehicles above 3,5t

a) Method of calculating the maximum weighted average toll

In accordance with Article 2., Annex III. of the Directive, the weighted average toll is calculated as a division of the allocated costs of the road network and tolling system on the traffic volume on the respective road expressed. In compliance with the Directive the buses are not included in the maximum weighted average toll calculation.

Maximum weighted average toll allocated on heavy goods vehicles is set by the following ratio:

Rmax = Ca / Vh

Rmax – Maximum Toll Rate (CZK/km) – Maximum weighted average toll
Ca – Cost allocated to heavy goods vehicles (CZK) – costs of roads and toll system allocated to vehicles subject to the toll based on the ratio of traffic volume of tolled vehicles to the overall traffic volume on the toll road.
Vh – Traffic Volume (vehicle kilometre) is the traffic volume of heavy goods vehicles.

b) Counted costs
The types of costs that can be counted into the calculation of the maximum weighted average toll consist of:

- Investment costs that are counted for the respective year in a size based on the period of depreciation. These include costs of construction, costs to purchase land, costs to conduct an archaeological survey, cost of project and inspection activities, costs of modernization of roads, telematics, and other related costs. EU grants are deducted from the investment costs depending on how they are used and they are eventually deducted appropriately in the respective programming period.
- Operating costs, which include the costs of maintenance and operation of roads, tolling system, telematics, and interests of loans, are counted all in the respective year.
- Costs of the toll system include investment costs on its construction and further expansion on motorways and expressways and they include also operating costs until 2016 when the contract with the present provider of services terminates.

Because planned costs are set by the SFDI budget for individual years, the discount rate and inflation are not included in the calculations and the maximum weighted average toll is calculated repeatedly for each year.

Costs included in the calculation of the maximum weighted average toll according to Article 2, Annex III. of the Directive:

C = I – G + E + T + M + F + O

C – Total Costs (CZK) – total costs included in the calculation of the maximum weighted average toll before allocation
I – Investment Costs (CZK) – annual share of construction costs on the road network, distributed equally along the period of depreciation starting in the year of expenditure
G – EU Grants (CZK) – annual share of received EU grants
E – E-toll Costs (CZK) – annual share of investment costs on the tolling system, distributed equally along the amortization period starting in the year of expenditure
T – Telematic Costs (CZK) – annual share of investment costs on road telematics on motorways, distributed equally along the period of depreciation starting in the year of expenditure
M – Maintenance (CZK) – annual costs of repairs and maintenance, including operating costs of the tolling system and telematics
F – Financial Cost (CZK) – annual financial costs – interests of credits
O – Operational Costs (CZK) – annual operating costs of the road network operator

c) Allocation of costs according to Annex III., Point 4. of the Directive
Both groups of costs stated above were further allocated:

- In proportion to the traffic volumes of tolled vehicles to the overall traffic volume which includes also vehicles that are not subject to toll. Traffic volumes were adjusted by the coefficient of allocation and then the coefficient of allocation Kv was calculated, which takes into account the level of road network damage by the operation of heavy goods vehicles;
- Owing to the reasons of known costs of the total length of tolled roads, the costs of maintenance were allocated in proportion of the tolled and total length of respective class of road by the coefficient Ks. The proportion of the traffic volume on tolled part and total roads length was used for allocation of investment, reconstruction, modernization and repair.

Incurred costs are allocated on tolled heavy goods vehicles and on tolled lengths of roads:

Ca = C x Kv x Ks
Ca – Cost Allocated to heavy goods vehicles
C – Total Costs (CZK) – total costs that are included in the calculation of the maximum weighted average toll rate before allocation
Kv – coefficient of cost allocation on tolled heavy goods vehicles
Ks – coefficient of reduction of toll road length or their traffic volume

7 CONCLUSION

The paper contains the overview of the basic specifications and activities connected with the implementation of the electronic toll system in the network of highways and other roads of the Czech Republic. The implementation of this system is an example of an indirect PPP model of financing, in which the investment and operating payments of the system are covered from the collected toll. The roll-out of the system to cover the full scope of the road network of the Czech Republic requires extensive cooperation among a number of entities participating in the implementation and operation of the system. It is also necessary to mention the cooperation of the research capacities of the Faculty of Transport of the Czech Technical University in Prague, particularly the FT CTU Expert Group of the Minister of Transport. With regard to the pressure on reduction of congestions, the proposal for differentiated toll during Friday afternoon hours when the traffic intensity level substantially rises in the highway implies recognizable effect on congestion reduction on the toll highway network in the Czech Republic. In any case, the whole situation calls for a detailed analysis, because there is (after a very simplified calculation) of approximately CZK 100 million (EUR 4.1 million) an increase in the annual collection of the electronic toll system in the Czech Republic on Friday due to by 50% higher tariffs in the time from 15.00 to 21.00.

In the end of the paper principles and results of a new methodology for calculating the weighted average toll rates in the Czech Republic are described. The methodology has been applied in the revision of this calculation by the European Commission in 2011.

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Technical Note - Participation in the Balloting Process of ASTM International

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ASTM International, formerly known as the American Society for Testing and Materials, is one of the largest voluntary standards development organizations in the world. It is a trusted source for technical standards for materials, products, systems, and services. There are 142 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 and the paper introduces the business of these ones. 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 ballot about 450 standards, guidelines, and their revisions every year, see Table 1.

Table 1: Number of ballots in specified committees, data come from author's record, i.e. they can differ slightly from official ones.

Committee	Year				
	2009	2010	2011	2012	Sum
	Number of ballots per committee in specific year				
C09 on Concrete and Concrete Aggregates	141	169	185	143	638
D04 on Road and Paving Materials	75	62	71	66	274
D18 on Soil and Rock	63	105	138	121	427
D35 on Geosynthetics	46	22	66	37	171
E07 on Nondestructive Testing	69	67	83	63	282
Sum in each year	394	425	543	430	
Total Sum within four years	1 792				

In connection with the author's Technical Notes, published in this journal in the years 2009, 2010, and 2011, and describing the activities of the mentioned committees, the aim of the Technical Note is to inform about the selection of technical issues solved in 2012 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 seem to be interesting relating to actual domestic tasks: revisions of specifications for concrete aggregates, test methods for the soundness of aggregates by use of sodium sulfate or magnesium sulfate, test methods for density, relative density (specific gravity), and absorption of coarse and fine aggregate, test methods for density and void content of freshly mixed pervious concrete, test methods for determining the total water content of freshly mixed concrete using microwave oven drying, and so on. New standards on test methods for scaling the resistance of concrete surfaces exposed to deicing chemicals and for the determination of one-point, bulk water sorption of dried concrete. Specification for lightweight aggregate for internal curing of concrete.

Committee D04 on Road and Paving Materials

Asphalt and bituminous materials have taken up a large part of the committee's efforts but not only, i.e., practices for the effect of water on bituminous-coated aggregate using boiling water, for quantities of materials for bituminous surface treatments, for the recovery of asphalt from a solution using the rotary evaporator, for random sampling of construction materials and for measuring the delimitations in concrete bridge decks by sounding. Specifications for fabrication and jobsite handling of epoxy-coated steel reinforcing bars, for plain and steel-laminated elastomeric bearings for bridges, for high load rotational spherical bearings for bridges and structures, for materials for bridge deck waterproofing membrane systems, for joint and crack sealants, hot applied, for concrete and asphalt pavements, and for lubricant for the installation of preformed compression seals in concrete pavements.

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 the practice for thin-walled tube sampling of soils for geotechnical purposes, test methods for laboratory compaction characteristics of soil using standard and modified effort, for the measurement of pneumatic permeability of partially saturated porous materials through flowing air, for the density of soil and rock in place by the water replacement method in a test pit, for water content and density of soil in place by time domain reflectometry, for deep foundations under static axial compressive load, static axial tensile load and under lateral load, and so on.

Committee D35 on Geosynthetics

Interesting test methods, guides, practices, and other documents were discussed by the Committee, e.g., the practice for the sampling of geosynthetics for testing, test methods for index puncture resistance of geomembranes and related products, for the strength of sewn or thermally bonded seams of geotextiles, for determining the coefficient of soil and geosynthetic or geosynthetic and geosynthetic friction by the direct shear method for biological clogging of geotextile or soil/geotextile filters, for deterioration of geotextiles through exposure to light, moisture, and heat in a xenon arc type apparatus, for evaluating the unconfined tension creep and creep rupture behavior of geosynthetics and for the evaluation of stress crack resistance of polyolefin geomembranes using notched constant tensile load test and so on.

Committee E07 on Non-destructive Testing

The non-destructive testing committee has been involved in various documents, i.e., practices for the acoustic emission examination of welded steel sphere pressure vessels using thermal pressurization, for the ultrasonic testing of flat panel composites and sandwich core materials used in aerospace applications, for electromagnetic (Eddy-Current) examination of seamless and welded tubular products, austenitic stainless steel, nickel, and similar alloys for determining the impedance of absolute eddy-current probes and for the examination of welds using the alternating current field measurement technique, guides for electromagnetic acoustic transducers (EMATs) and for eddy-current testing of conducting materials using conformable sensor arrays, and so on.

SUMMARY AND ACKNOWLEDGEMENT

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

Instructions to the authors

1 GENERAL GUIDELINES

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

2 TITLE, AUTHORS, AFFILIATIONS

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