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Attitudes of Czech Drivers to Issue of Drinking and Driving – Development in Time and International Comparisons

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ABSTRACT: This study deals with attitudes of Czech drivers to the issues of drinking and driving, on the basis of SARTRE (Social Attitudes to Road Traffic Risk in Europe) surveys carried out during 1991 – 2002 in European countries. The results of the Czech part of SARTRE 4 show that drivers in the Czech Republic maintain their support to tightening of sanctions against drinking and driving and support, more than ever before, the technical measures which prevent drinking and driving. In general, they stand against drinking and driving and, based on their words, they rarely violate the drinking and driving regulations concerning even the slightest amount of alcohol. On the other hand, the support for increasing the maximum legal alcohol level in blood has increased and the extent of this support is also higher in the international comparison. A positive feature is the increased level of experience with the enforcement of drinking and driving regulations and the resulting increased perceived probability of being checked when driving.

KEY WORDS: Road safety, drink driving, car drivers.

1 INTRODUCTION AND METHOD

SARTRE (Social Attitudes to Road Traffic Risk in Europe) is an international comparative project that maps the attitudes of European road users to the most important aspects of road safety (speed, seat belts, alcohol and drugs, fatigue, style of driving, legislation and control, causes of traffic accidents, importance of road safety in relation to other social issues) using a uniform methodology in every participating country. Four SARTRE surveys have been carried out until now – SARTRE 1, including 15 countries, in 1991, SARTRE 2, including 19 countries, in 1996, SARTRE 3 with 23 countries in 2002 and 2012, SARTRE 4 was completed, including 19 European countries. The Czech Republic participated in all four surveys.

While in the previous surveys only car drivers were considered, SARTRE 4 also deals with the views expressed by motorcyclists and other road users (pedestrians, cyclists). The Czech sample (similarly to samples of other countries) includes 1002 respondents, out of which 600 were car drivers, 202 motorcyclists, and 200 pedestrians and cyclists. The groups of motorcyclists and other road users are deliberately overrepresented to achieve statistical confidence in the analyses (Cestac et al., 2012).

The decisive phase of the project, a questionnaire survey, was carried out at the end of 2010. The method of quota sampling by age, sex and occupation of the basic set (road users over eighteen years of age) gave a sample of respondents who, in face-to-face interviews, answered questions put in an extensive standardized questionnaire.

Using the SARTRE data, we address in this study the attitudes of the group of Czech car drivers to the issues of drunk driving. The attitudes of Czech car drivers expressed in SARTRE 4 interviews are compared with attitudes of drivers from other participating countries, and with data from previous SARTRE researches.

The range of the questions included in the SARTRE questionnaire enables complex description of drinking and driving problem from road users' point of view. The respondents were asked to express their agreement or disagreement with several statements related to driving under the influence of alcohol, and then they were asked specifically to their behaviour in this regard. They also expressed their views on the maximum permitted level of alcohol in blood and police BAC checks.

However, the issue of drink driving is one of the most difficult in terms of international comparisons, because the legal maximum blood alcohol levels differ across Europe and a simple comparison could be misleading, so we mention them only where it makes sense (and where the position of the Czech Republic in the international context is in some way interesting). The opportunity to compare views of drivers over time is also somewhat limited because some questions were not asked in past projects or were phrased differently. A substantial part of the output, however, can be compared.

2 SUPPORT OF MEASURES AGAINST DRINK DRIVING

At the beginning of the interview, respondents were asked whether they would consider beneficial certain devices or measures to prevent drink driving.

2.1 "Alcolocks" to prevent the driver from driving if over the legal alcohol limit (for all drivers)

Table 1: Opinion of Czech drivers on the benefits of alcohol interlocks required for all.

	Very	Rather yes	Rather no	Not at all
1996	23.3%		76.7%	
2002	37.5%		62.5%	
2010	**40.8%**	**34.8%**	**16.4%**	**8.0%**

Compared with the previous surveys (Skládaná et al., 2005), there was a significant shift in the attitudes of Czech drivers towards this device. While in 1996 only 23.3% of drivers considered alcohol interlocks beneficial, in 2002 their proportion increased to 37.5% and in the last survey, drivers in support to this technology prevailed significantly – 75.6% in total. The level of their agreement is not much affected by the question if the device would be required for all or only for those who have already had problems with alcohol (see Chapter 2.2).

2.2 "Alcolocks" only for drivers who have already violated drinking and driving regulations

Table 2: Opinion of Czech drivers on the usefulness of alcohol interlocks for drivers who have already had problems with alcohol.

Very	Rather yes	Rather no	Not at all
46.8%	**29.3%**	**16.4%**	**7.5%**

2.3 More severe penalties for driving under the influence of alcohol

Table 3: Opinion of Czech drivers on more severe penalties for driving under the influence of alcohol.

	Fully agree	Fairly	Undecided	Rather disagree	Absolutely disagree
2002	90%		6.2%	3.8%	
2010	**60.7%**	**26.9%**	**8.0%**	**2.2%**	**2.2%**

This question has already been asked in the SARTRE 3 project (Cauzard et al., 2004). The proportion of agreement and disagreement responses remained practically unchanged, the vast majority of drivers generally supports more severe penalties for driving under the influence of alcohol.

3 ATTITUDES TOWARDS DRIVING UNDER INFLUENCE OF ALCOHOL

Respondents were given four statements that could be classified in a four-point rating scale according to the level of their agreement from “very” to “not at all”.

3.1 You can drink and drive if you drive carefully

With the first statement, “You can drive under the influence of alcohol if you drive carefully”, only 8.8% of drivers surveyed agreed, mostly only partially. Majority of respondents tended to disagree, 72.3% of the respondents disagreed at all. As expected according to previous research experiences (Baum, 2000; Cauzard et al., 2004; Skládaná et al., 2005), the results differed by gender. Females refused this statement more often than males (87.4% of males vs. 96.1% of females).

Table 4: Level of agreement among Czech drivers with the statement “You can drive under the influence of alcohol if you drive carefully”.

Very	**0.8%**
Fairly	**8.0%**
Not much	**18.8%**
Not at all	**72.3%**

3.2 Driving under the influence of alcohol increases the risk of conflict with other road users

On the other hand, most drivers agreed with the phrase “Driving under the influence of alcohol increases the risk of conflict with other road users” that was declined only by 8.5% of the respondents. Males and females agreed to the same extent, females just more inclined to the stronger form of consent; and there are no significant differences between the age groups.

Table 5: Level of agreement among Czech drivers with the statement "Driving under the influence of alcohol increases the risk of conflict with other road users".

Very	**66.3%**
Fairly	**25.2%**
Not much	**2.7%**
Not at all	**5.8%**

3.3 If you drive under the influence of alcohol, you will be checked and fined by the police

As for the statement "If you drive under the influence of alcohol, you will be checked and fined by the police" agreements prevailed, but respondents chose mostly less decisive forms of their consent or disagreement. Females agreed only slightly more often than males (75.5% of females, 71.4% of males). Among the age groups, the group of 35 – 44 years of age differs; their disagreement with the statement (34.8%) is significantly more frequent compared to the rest of sample. On the contrary, in the age group of 45 – 54, the disagreement is less frequent (17.9%).

Table 6: Level of agreement among Czech drivers with the statement "If you drive under the influence of alcohol, you will be checked and fined by the police".

Very	**24.3%**
Fairly	**48.8%**
Not much	**20.8%**
Not at all	**6.0%**

3.4 Most of your friends would drive under the influence of alcohol

The statement "Most of your friends would drive under the influence of alcohol" is phrased less generally than the previous statements and has usually been met with disagreement (93.1%), but not always decisive, 49.3% of the respondents chose the more cautious form "not much". Females are somewhat clearer in this case again (48.2% of females vs. 40.5% of males "Not at all"). What is worthy of note, however, is the difference between the lowest and highest age category (see Table 8). It is obvious that on the concrete level, drinking and driving is less tabooed in the youngest generation than among senior drivers. In an international comparison (Cestac et al., 2012) however, together with Sweden, Finland, Hungary and Ireland we are still among to the countries with the lowest proportion of respondents who expressed agreement with that statement.

Table 7: Level of agreement among Czech drivers with the statement "Most of your friends would drive under the influence of alcohol".

Very	**1.3%**
Fairly	**5.5%**
Not much	**49.3%**
Not at all	**43.8%**

Table 8: Level of agreement among Czech drivers with the statement “Most of your friends would drive under the influence of alcohol” according to the age of respondents.

	Very	Rather yes	Rather no	Not at all
18 - 24	**1.4%**	**9.7%**	**52.8%**	**36.1%**
65 +	**0.0%**	**0.0%**	**46.9%**	**53.1%**

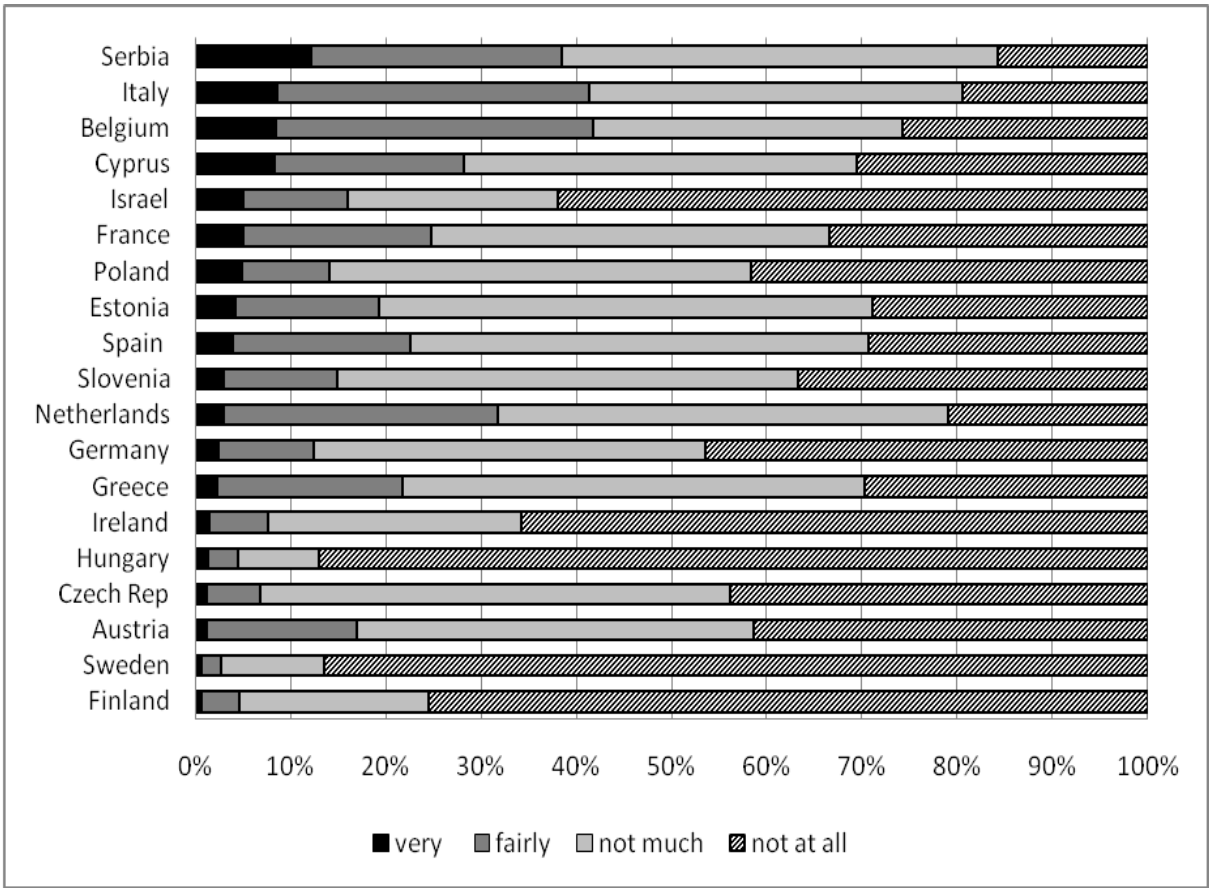

Figure 1: Level of agreement with the statement “Most of your friends would drive under the influence of alcohol”, international comparison.

4 BEHAVIOUR OF DRIVERS IN RELATION TO DRINKING AND DRIVING

In the next block, drivers were asked about their own behaviour in relation to driving under the influence of alcohol. The first question was about drinking even a small amount of alcohol before driving over the last month – generally, such an amount of alcohol that should not cause exceeding the legal limit of alcohol in the driver’s blood (in fact or in the driver’s opinion); the second question related to drinking of such an amount of alcohol, which may cause the exceeding of the limit. This, however, in countries with a limit of 0.0 g/l, as the Czech Republic, means something different than in countries with the permitted level of 0.2 – 0.5 g/l. Therefore, international comparison is not of great explanatory value here, and for this reason, it is not mentioned in this chapter.

4.1 Over the last month, how often have you driven a car after having drunk even a small amount of alcohol?

Among the respondents, 86.3% of them answered this question as “never”, 11% “seldom”. The answer “never” was more often used by females and all respondents of the age group of 65+ (over 90% also in the age groups of 18 – 24 and 45 – 54). Answers “sometimes”, “often” and “very often” were chosen only rarely; they do not occur significantly often in any age or gender category.

Table 9: Frequency of consumption of a small amount of alcohol before driving among Czech drivers.

Never	**86.3%**
Seldom	**11.0%**
Sometimes	**1.5%**
Often	**0.7%**
Very often	**0.5%**

4.2 Over the last month, how often did you drive a car, when you may have been over the legal limit for drinking and driving for the Czech Republic, a “zero tolerance”?

Considering the legal limit 0.0 g/l, it is not surprising that in the Czech sample the question specifically concerning the amount of alcohol, when the limit may have been exceeded, was answered practically the same as the previous question, also with respect to age and gender.

Table 10: Frequency of driving after possibly drinking alcohol over the limit among Czech drivers.

Never	**87.8%**
Seldom	**10.0%**
Sometimes	**1.5%**
Often	**0.2%**
Very often	**0.5%**

5 MAXIMUM LEGAL BLOOD ALCOHOL LEVEL

Drivers were also asked two questions about the permitted levels of alcohol. The first one examined respondents’ opinion on how much alcohol they can drink before driving. Answers were reported in fixed units, where one unit matched to the amount of alcoholic beverage containing about 10 g of alcohol – for example a small glass of beer or a decilitre of wine. The second question concerned the drivers’ opinions on what should the limit be.

5.1 In your opinion, how much alcohol can we drink before driving and still remain under the legal limit, a “zero tolerance”?

Almost three quarters of the respondents reported that to comply with the limit of 0.0 g/l they cannot drink any alcohol, and 21.8% reported one unit. There is a significant difference between males and females, more females than males reported zero option (82.1% versus 67.3%) while 7.0% of males in comparison with 0.8% of females believed that they can drink up to two units of alcohol. Age does not play very significant role, only in the age group of 65+, there is no respondent indicating more than one unit, and 84.4% does not accept any alcoholic beverage. In comparison with 2002 (Skládaná et al., 2005), there is **a drop by 11%** in the proportion of the respondents who believe that to comply with the legal limit they can not drink any alcoholic beverage.

Table 11: Opinions of Czech drivers on amount of alcoholic beverages that driver can drink and still remain under the legal limit, in units.

0	**73.7%**
1	**21.8%**
2	**4.3%**
3	**0.2%**

5.2 What should be the legal limit for alcohol in blood?

Maintaining the current legislation, i.e. the limit of 0.0 g/l, was supported by 78.4% of the respondents; 21.4% would increase the limit. One single respondent was for an unlimited consumption of alcohol before driving. In comparison with the previous SARTRE surveys (Skládaná et al., 2005), the rate of those who support the limit increase rose from 14.4% in 1996 and 13.6% in 2002 to 21.4%. The supporters of higher limit can be found rather among males (26.7%) and in the age group of 35 – 44 (29.3%).

In international comparison (Cestac et al., 2012), the Czech Republic is now a country with the highest rate of those who support the current limit increase, even compared to countries that have legalized very low level of alcohol (Sweden, Estonia, Poland, Serbia) or also 0.0 g/l (Hungary). Despite recent tightening up the penalties for drunk driving in these countries, we can find high support to the existing regulations in Hungary, and over 90% drivers supporting establishing of the limit of 0.0 g/l in Estonia and Poland. In order the Czech Republic does not take the course against the European trend towards reducing the alcohol limit, it would probably be appropriate to make steps to renew the support to the existing legislation.

Table 12: Support of the existing maximum permitted level of alcohol in blood before driving among Czech drivers.

	2010	2002	1996
Current state	**78.4%**	**84.6%**	**82.4%**
Higher permitted level	**21.4%**	**13.6%**	**14.4%**
Any amount of alcohol	**0.2%**	**1.8%**	**3.2%**

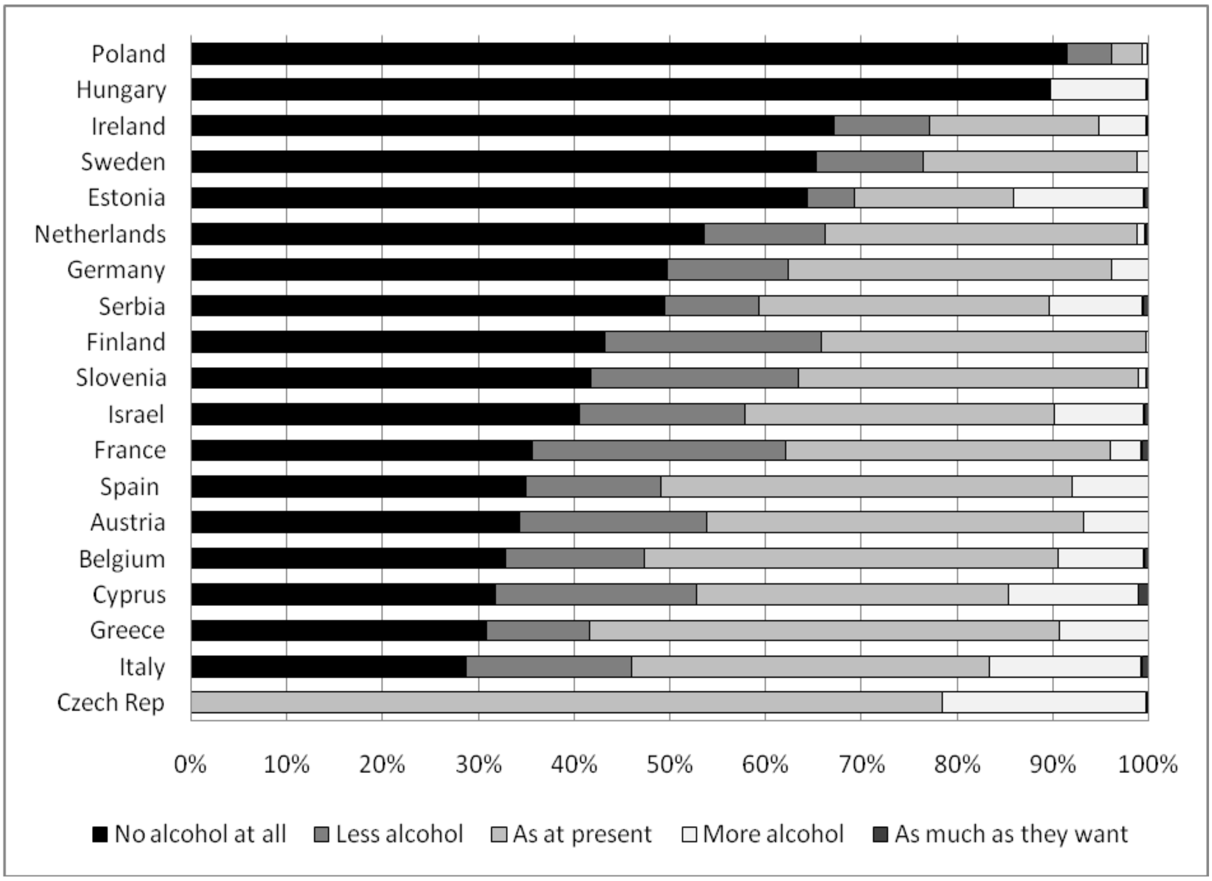

Figure 2: Support to the current maximum permitted level of alcohol in blood before driving, international comparison.

6 POLICE ENFORCEMENT

Two questions related to checks for alcohol behind the wheel by the police – its frequency and odds of occurrence on a typical car journey.

6.1 In the past 3 years, how many times have you been checked for alcohol while driving a car?

The largest proportion of the respondents, 42.2%, reported that within the past three years they have not been checked by police. 31.8% of drivers were checked once and 26% more than once. The likelihood of being checked naturally rises with increasing driving performance. Compared to the last SARTRE survey results (Skládaná et al., 2005) there was a significant (by 26%) drop in the proportion of respondents who have not been checked for alcohol over the past three years, and also in an international comparison (Cestac et al., 2012), the Czech Republic ranges among countries with the lowest proportion of drivers who have not been checked.

Table 13: Experience of Czech drivers with checks by the police in the past three years.

	2010	**2002**
Never	**42.2%**	**68.3%**
Only once	**31.8%**	**19.8%**
More than once	**26.0%**	**11.9%**

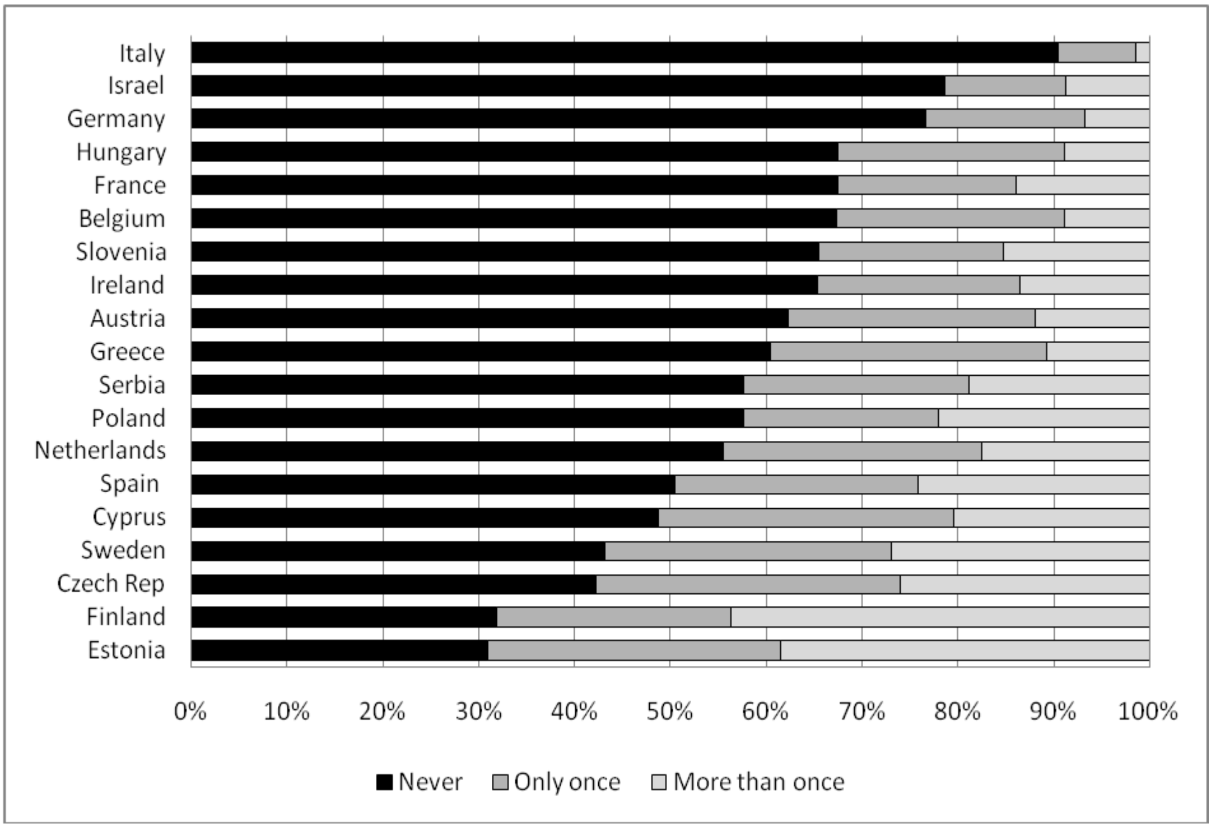

Figure 3: Experience with police check over the past three years, international comparison.

6.2 In your opinion, on your typical car journey, how likely is it that you will be checked for alcohol?

In terms of the effectiveness of police enforcement, the expectation of drivers that they will be checked - so called subjective risk - plays an important role together with actual frequency of checks. It can be said that according to the results of the survey, the expectations very closely reflect the factual experience of respondents (Table 15). In comparison with the previous surveys (Skládaná et al., 2005), the proportion of those who expect to be checked sometimes or often during their journey increased. In an international comparison (Cestac et al., 2012), Czech drivers mostly expect to be checked sometimes or often.

Table 14: Perceived probability of being checked for alcohol among Czech drivers.

	2010	**2002**	**1996**
Never	**13.2%**	**12.4%**	**12.2%**
Rarely	**33.8%**	**50.3%**	**60.9%**
Sometimes	**33.3%**	**24.4%**	**20.3%**
Often	**12.3%**	**5.9%**	**3.6%**
Very often	**3.3%**	**4.0%**	**1.9%**
Always	**4.0%**	**3.0%**	**1.1%**

Table 15: Perceived probability of being checked for alcohol according to frequency of checks over the past three years among Czech drivers.

		Likelihood of check					
		Never	Rarely	Sometimes	Often	Very often	Always
Number of checks in the past 3 years	Never	**26.9%**	**39.9%**	24.1%	4.0%	1.6%	3.6%
	Only once	3.1%	**42.9%**	**37.2%**	10.5%	1.6%	4.7%
	More than once	3.2%	12.8%	**43.6%**	**28.2%**	8.3%	3.8%

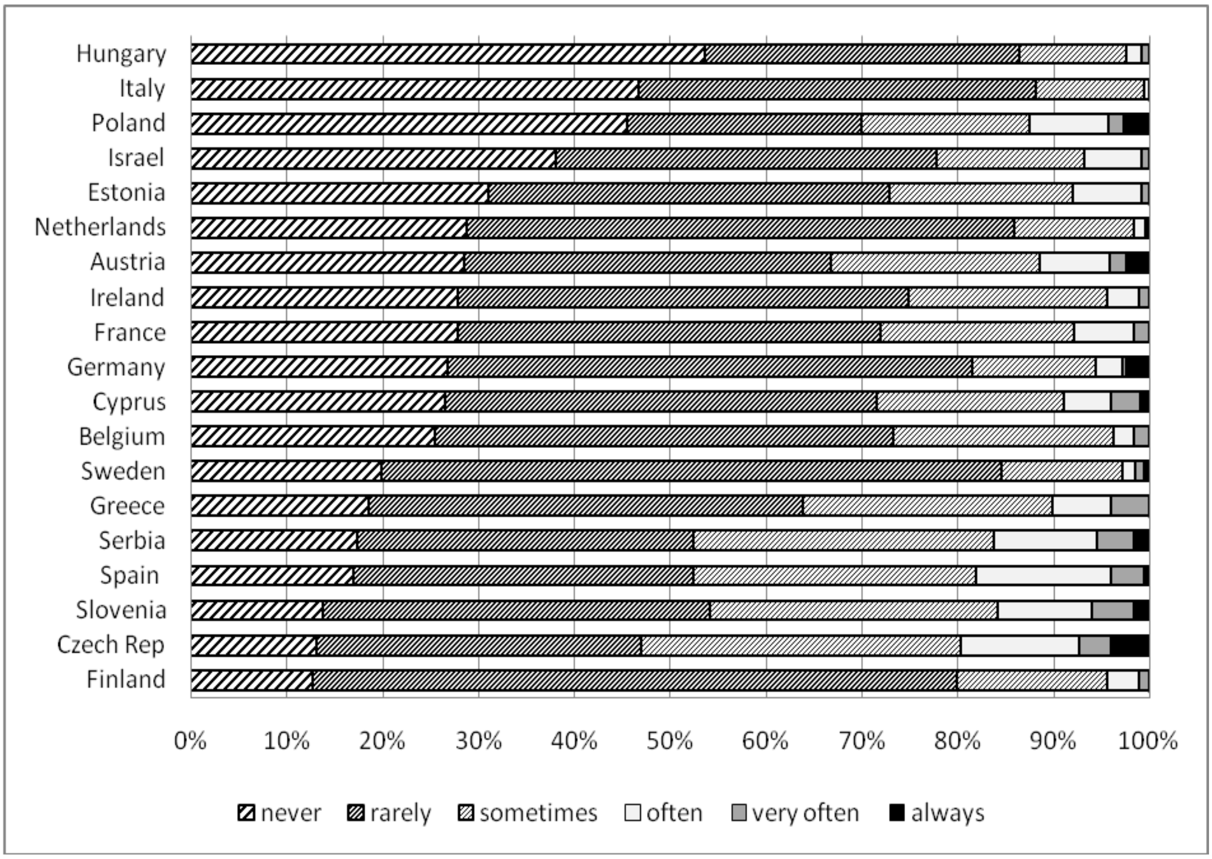

Figure 4: Perceived probability of being checked for alcohol, international comparison.

7 CONCLUSION

Behaviour, experience and attitudes of Czech drivers with respect to the issue of drinking and driving have evolved since the past SARTRE survey, reflecting attitudes to alcohol in the society, but also reflecting traffic safety activities in the past period.

To some extent, traditional negative attitude persists towards drinking and driving. Respondents generally disagreed with the statement “Most of your friends would drive under the influence of alcohol” – in an international comparison, the Czech Republic belongs to the countries with the lowest level of approval. As in previous surveys, they favoured more severe penalties for driving under the influence of alcohol, more often than before they consider the use of alcohol interlocks beneficial, they agree with the statements referring to the risks of driving under the influence of alcohol, and usually do not drive when having consumed alcohol.

Some results, however, point towards some easing opinions regarding alcohol and its maximum permitted levels in blood while driving a motor vehicle. The proportion of respondents who believe that they can drink a small amount of alcoholic beverages without getting over the legal limit of 0.0 g/l increased and, particularly, there is rise in the percentage of drivers who would welcome a limit increase. This development is in direct conflict with the European trend of reducing the maximum permitted level of alcohol, which is clearly also accepted by the general public in European countries – in international comparison, the Czech sample has the largest proportion of those who wish that the limit was increased. Some indication of changes can also be observed when comparing certain attitudes (not behaviour) in the age groups of the youngest and the oldest drivers – the younger ones admit that their friends drive under the influence of alcohol, which is absolutely denied by the older group.

A significant change is apparent in the experience of the respondents with police checks for alcohol. The proportion of those who have not experienced any check over the past three years significantly decreased, and in an international comparison, the Czech Republic ranges among the countries with the lowest proportion of such drivers. This is reflected in the rise of the perceived probability of being checked – drivers now consider the probability of being checked higher than before.

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Value Engineering and its Application in the Design and Implementation of a Logistics Centre

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ABSTRACT: All large projects, from their inception to their completion, follow certain processes, undergo evaluations of different designs, while at the same time, they ensure project functionality at certain costs acceptable to the owner. The most effective process to manage costs is a process which puts emphasis not only on functionality, but also keeps prices and schedule in check from the project beginning to the completion of construction.

To keep project costs within certain parameters, there is a need to begin the project with a realistic budget and to have reliable pricing data. In addition, during the development phase, the project costs must be recalculated and, if necessary, adjusted (Bína et al., 2011). Another tool to increase the project value or decrease costs is to perform Value Engineering, i.e. an analysis of project functionality, specifications, tender documents and other project aspects, by a team of experts.

This paper describes Value Engineering and how such experts' efforts would be applied on transportation projects.

KEY WORDS: Transport projects, project re-evaluation, Value Engineering.

1 INTRODUCTION

Value engineering (Mandelbaum & Reed, 2006) is trying to find a balance between functionality, quality, safety and costs of construction and subsequent maintenance.

Logistics centre projects, from their beginning to their completion, follow certain processes, undergo evaluations of different designs, while at the same time, they ensure project functionality at certain costs acceptable to the owner.

In the phase of preparation, it is possible that certain proposals, arising from contracting authority or from the requirements of public administration bodies, can lead to cost overruns of the project from the initial pre-estimate. This can happen because of controllable reasons (location, route selection, number of intersections, etc.) or because of reasons where contracting authority has low or no impact (costs of materials, inflation, etc.).

It is necessary to set up a system of individual steps in the preparation and implementation that ensures quality of the management process of the project and of control of project costs. This procedure will ensure optimal relation between the price and functionality while keeping required quality and safety (Khane, 1986).

The most effective process to manage costs is a process which puts emphasis not only on functionality, but also keeps prices and schedule in check from the project inception to the completion of construction.

2 INPUT DATA ANALYSIS

- Commodity flows - for logistics terminal in the region, network of commodity flows (connections with partners in the “hub” terminals), forecasts of new commodity flows:
  - Import and export commodity flows in relation to places of production and consumption, which are located in the operation radius of the terminal, including links to the industrial zone;
  - Commodity flows that have a transit character between logistics terminals of the network;
  - Logistics operations in its own logistics terminal.

Analysis and forecast of commodity flows are an essential pillar of the methodological model. An expert proposal should aim to ensure the passing of analysed commodity flows through logistics terminal.

Forecasting methods, heuristic and expert practices can be used.

- Costs of implementing the logistics terminal;
- Costs of related transport infrastructure, which must correspond with the performance of the logistics terminal. Besides the road and rail infrastructure, it must also grant any necessary access to inland waterways transport, maritime and air transport. An external investment input from the public funds can be used for partial coverage of these costs;
- Costs of land based on size and price (the used site for logistics terminal must be in accordance with the planning documentation). The site must correspond with the spatial requirements of related transport infrastructure and with logistics operations in the terminal;
- Availability of transport corridors for road, rail and water transport. When considering transport corridors, especially in Europe, it is necessary to think about prognosis and schedules of development of new transport corridors.

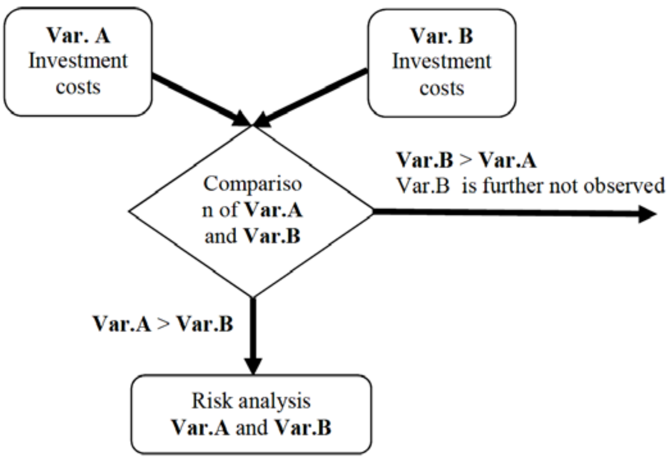

Figure 1: Decision-making process in Var. A and Var. B of related transport networks.
Source: author

- Var. A - external transport networks that exist at the design phase of a logistics terminal. The solution includes a network of road, rail, water and air transport in accordance with the input of technical-economic parameters for a logistic terminal.

- Var. B - external transport networks for which there is a time schedule of implementation and which can be considered for designing a terminal. This option is processed only if the implementation of logistics terminal (PLC) is being prepared in an area with construction of new infrastructure to which it would be beneficial to lead the related transport network.

3 EVALUATION OF ECONOMIC AND SOCIAL BENEFITS

When designing a logistics centre, not only economic benefits should be considered, but the whole society benefits (including intangible ones), too. When considering public support to a project of a public logistics centre, it is obviously necessary that society benefits are quantified at least to the level of the required public support. When implementing multimodal logistics centre, social benefits are achieved - concerning employment, improvement of the environment, lower accident rates, etc.

- Economic benefits of a terminal are divided into three basic groups:
  - Benefits from logistics terminal operations (container terminals, storage, etc.);
  - Benefits from logistics terminal activities;
  - Benefits from non-logistics terminal operations.

A necessity for a new container terminals can be defined by expert estimation. Society benefits can be then calculated (development of the region, new jobs, reducing transport externalities, etc.).

- Society benefits of a terminal (PLC)
  - Creating cooperating technological parks and industrial zones;
  - Increase in economic performance of the adjacent micro-region, towns and municipalities;
  - Improvement of environmental conditions and health because the existence of logistics terminals with access to road and rail transport is a condition for a change in freight transport from road to rail or waterway;
  - Creation of new job opportunities during construction of PLC, related infrastructure and in subsequent operation of PLC, as well as in related technological parks and industrial zones - there is a significant socio-economic effect. Global logistics chains are also a platform for deployment of information technologies from economic point of view. These facts lead to creation of jobs as well to highly qualified jobs;
  - The transfer of freight transport from road to rail network or the network of inland waterways has a significant impact on the environment and health especially in terms of:
    - Reduction of emissions (CO_2);
    - Reduction of noise pollution;
    - Reduction of congestion on the road network in particular, reducing accidents and fatal consequences.

Logistics centres have very similar process structures in contrast to technological parks and industrial zones. The existence of links between technological and logistic parks is very useful for the operation of both parts because of economic reasons and society benefits. The basic criteria for the methodology for designing logistics terminals are shown in Figure 2.

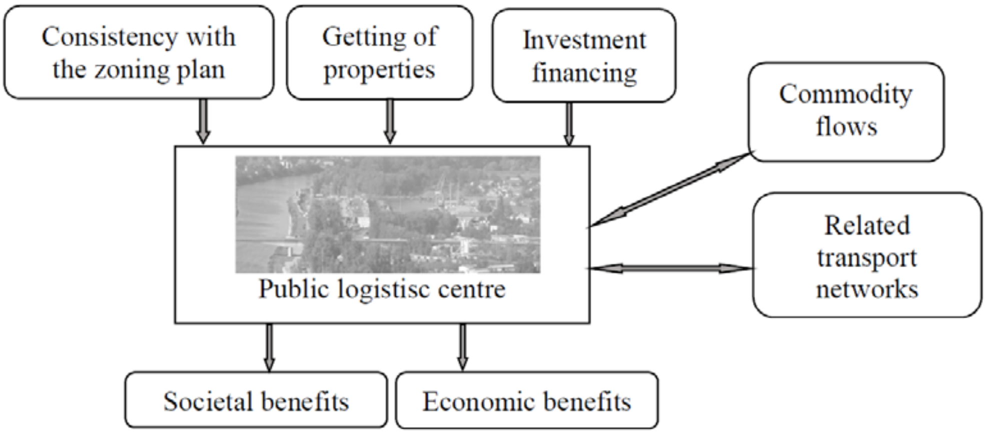

Figure 2: Basic criteria for the methodology for designing logistic terminals.
Source: author

4 RISK ANALYSIS

In terms of transport modes, the risk analysis is performed for road and rail connections, and only in the case when future external transport network is realizable in accordance with the preparation of the construction of a logistics terminal.

When assessing variants of a project, variety of methods can be used to find the optimal solution. For heuristic methodological model of expert design of logistics terminal that does not have exact data on the basis of detailed engineering, the method of risk analysis is chosen. It is based on the evaluation of the level of risks that are brought by individual variants. The significance of risk factors is assessed by a group of experts in two aspects:

In terms of *probability of risk factor occurrence* (P), linear scale is usually selected:

Degree	The occurrence of a risk factor is
1	*Improbable*
2	*Low likelihood*
3	*Highly likely*
4	*Nearly certain*

In terms of impact, i.e. *intensity of negative impact of the occurrence of risk factor* (D), non-linear scale is usually selected:

Degree	Impact of the occurrence is
1	*Negligible*
2	*Minor*
8	*Serious*
16	*Critical*

In terms of significance, it is necessary to consider factors whose occurrence is certain with the critical impact when they occur. The risk factors whose probability of occurrence is indeed improbable or small but negative impact may be up to critical, have to be regarded as significant. For these reasons, the linear scale is chosen instead of the non-linear scales for evaluating the negative impact for the probability of risk factor occurrence.

The interaction between a risk factor and intensity of the impact can be defined as follows:

As a model situation, selected P x D values can be used for determining the acceptability of risk as follows:

P x D	**risk assessment**
1 - 8	risk is acceptable
16-24	risk is conditionally acceptable
32-64	risk is unacceptable

An example illustration is shown in a model example of assessing two variants of road connection of a logistics terminal to an external road network in the above mentioned variants Var. A and Var. B.

Risk factors may be defined as follows:
A - Risk of exceeding investment costs (A)
B - Risk of acceptability of investment cost (B)
C - Risk caused by investment costs (A)
D - Risk caused by investment costs (B)
E - Risk of non-compliance with project parameters (A)
F - Risk of exceeding investment costs (B)
G - Risk of administrative and authorization procedures (A)
H - Risk of higher operating costs (B)
I - Risk of non-compliance with construction schedule (A)
J - Risk of unsecured financing (B)
K - Risk of public disapproval (A)

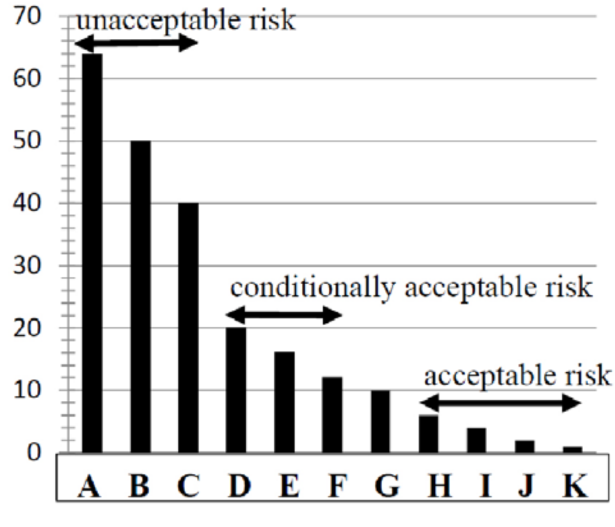

Figure 3: A model of results of risk analysis variants of road connection of a logistic terminal to external road network.
Source: author

An example of evaluating intensity of negative impact of the above mentioned exemplary risk factor “Exceeding the investment costs” can be the maximum value. In some projects that are financially managed by the proposed methodology, the excess of investment costs more than the tolerated deviation would generate an additional necessary step - financial control of the project.

An example shows a situation where the location of the construction is designed on a land with uncertain property relations, which can both mean more financial resources and potential shutdown of the realization of the project.

As it is obvious from the definition of risk analysis, a vital and essential role is played by the level of expert evaluation and qualifications and experience of the expert team members.

Risk Analysis identifies risks of the proposed variants and also defines critical points that need to be addressed during the project implementation. Results of assessment of this sub-model are:

- Final variants of realizable related infrastructure;
- Investment costs of individual final variants;
- Terms of implementation;
- Method of financing.

For the process of risk analysis, the method of Universal Matrix of Risk Analysis can be used. It has two stages: in the first – members of the expert group identify various segments of the project and identify resources which may be risky for these segments. In the other (numerical) stage the seriousness of the danger is estimated by using matrix UMRA and identified risks are quantified by estimated seriousness. It is necessary to identify all risk factors, from the beginning of project preparation to its implementation and its subsequent operation.

5 DEVELOPMENT OF INVESTMENT PLAN, CBA AND PROJECT DOCUMENTATION

5.1 Investment plan

Investment plan is a basis for justification of necessity of action and for the evaluation of its effectiveness. It contains construction technical description including the characteristics of the property and requirements for conditions for efficient use of the acquired assets and for evaluation of project benefits to deal with employment.

Already at this stage, preliminary estimation of costs must be available. It is prepared by experts on projects and construction work prices. Most of these first “estimations” are based on historical data (prices of units and segments, such as number of m^2 of road, bridge in question, etc.). These cost estimations are then used in the process of economic evaluation of usefulness of the project.

For example, to determine the cost of the infrastructure the Perpetual Inventory Method (PIM), method was used. It is based on knowledge of annual costs spent in the past on the road infrastructure, and in this method the pricing regulations 2008 (Moos et al., 2007) were used to determine the value of the motorway network built from 1978 to 1989.

In the next stages of the project preparation and in implementation, changes in the project budget based on project changes must be made (Nováková, 2010). If there is a disproportionate increase in costs compared to the estimated costs on the project, the particular part is returned for reprocessing either at the stage of the engineering preparation or the extra costs of the project must be justified in the implementation stage, and subsequently approved while additional funding is ensured.

In terms of costs data, the designed methodology can operate with:

- Knowledge bases and rules of individual parts of a project;
- Expert estimations of other missing data;

- Acceptance of data from similar projects (historical data);
- Combination of historical data and actual calculated costs.

5.2 Cost-benefit analysis (CBA analysis)

Dynamic methods are used in transport projects for cost-benefit analysis (CBA) of projects due to their multi-year implementation of projects and many years of useful life of these projects. Regarding the economic and analytical evaluation of transport projects, it is necessary to consider the value of money in time. All cash flows are discounted to their present value for comparisons and decision making processes. The analysis includes the evaluation of essential characteristic indicators, on basis of which a decision is made regarding the acceptability or unacceptability of the project.

We use the following terms for calculation of these indicators:

Discount Rate in investment analysis
The discount rate is an interest rate at which commercial banks can obtain loans from the central bank. In economic analyses, the term of *nominal discount rate* is used. It reflects the return on capital, risk level and inflation and is calculated using the formula:

According to nominal discount rates, future cash flows are discounted (recalculated) to the present value.

Net Present Value (NPV)
NPV is defined as a difference between the discounted cash flows from the implemented project, e.g. expected profit after tax, depreciation and other revenues, and capital investments in the project. If the project implementation takes several years (which is common in transport infrastructure projects), investment costs are discounted each year. The discount rate includes the interest rate, inflation rate and risk factors. It is calculated using the formula:

$$NPV = \Sigma CF_n \cdot \frac{1}{(1+NDR)^n} - C$$

where
$CF_{n = 1, 2, \ldots, N}$ …. discounted sum of all cash flows received from the project
NDR …. nominal discount rate (in %/100)
C …. investment costs of the project
The project is acceptable for NPV ≥ 0, the project is unacceptable for NPV < 0

Internal Rate of Return (IRR)
This indicator evaluates annual profits from the project operation after tax in each year of the project life and an average annual value of fixed assets at net book value during the life of the project. This formula is used:

$$IRR = \frac{\sum_{i=1}^{N} AP_n}{N.AV_n}$$

where
AP_n …. annual profits from the project operation after tax
AV_n …. average annual net book value of the project

individual years of the project life*N* … years of project life
The project is acceptable for IRR ≥ NDR, the project is unacceptable for IRR < NDR.

Payback period

It is the time (years) when the cash flows from the investment, expressed as a discounted cash flows, will reach the discounted initial capital investments. The payback period is calculated using the following formula:

IC … investment costs of the project
AP_n … annual profits from operation of a project after tax in each year of the project life
annual depreciation of investment costs of the project in each year of the project lifeindividual years of the project life*N* … years of project life
The project is acceptable if the payback period is lower or equal to the lifetime of the project.

Cost-benefit analysis (CBA) includes the sensitivity analysis, i.e. calculating the impact of significant assumptions and parameters of financial (cash) flows to the values of key indicators of the analysis according to the above mentioned. For each changed assumption we calculate the percentage change in the criteria-indicators.

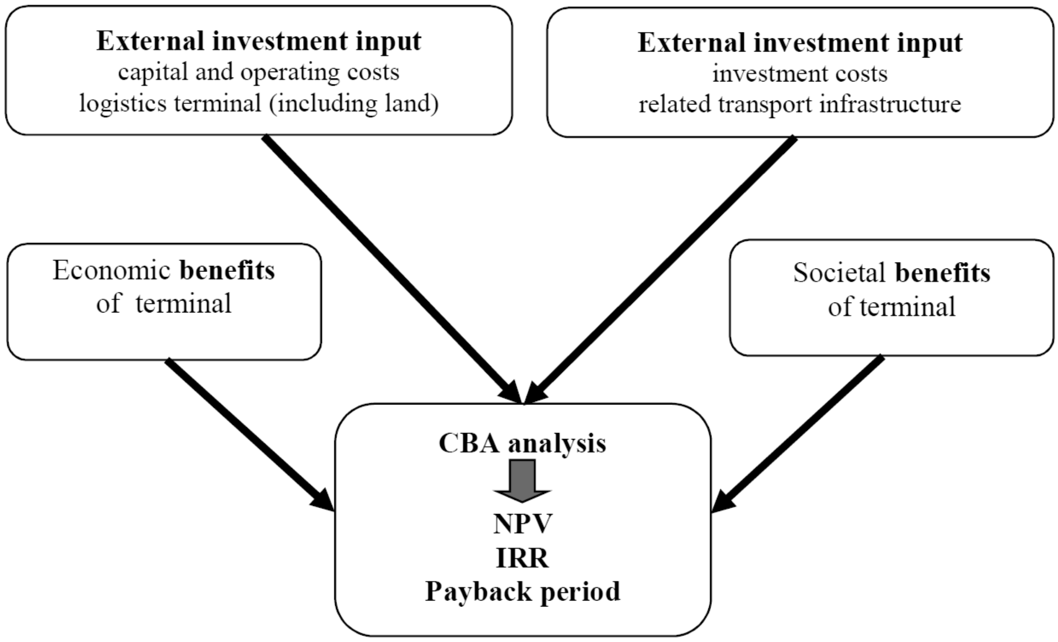

Figure 4: Input parameters for the CBA analysis of logistics terminal.
Source: author

Technical and economic parameters of related transport networks are again designed to provide optimum commodity flows. Changing of these networks is again necessary in the case of a negative result of CBA.

External investment inputs are variable in the case of a negative result of CBA. Regarding the fact that public resources are concerned, they may be changed in the design stage due to effects of external environment.

5.3 Production of project documentation

In case it is decided to implement the project, it is necessary to specify the preparation of the planning permission documentation including the cost calculation, under which the construction is set on specific plots. In addition, surveys are processed - geodetic and geological surveys, and technological process is designed. At this stage, the documentation EIA (Environmental Impact Assessment) - assessment of the impact of the construction on the environment is also prepared. If the result of this calculation is a disproportionate increase in costs compared to the estimated costs of the project, it is necessary to prepare an analysis and justification of this fact.

At this stage, contracting authority can still decide either to reprocess the project or to approve the price increase. The result is an issued planning permission.

The proposed procedure of the financial management of the project operates with these assumptions:

- From the stage when the final planning permission is issued, the cost budget of the project will be monitored throughout the course of the project while the deviation from the cost calculation in the documentation for planning permission may not exceed + -10%;
- In case this deviation is exceeded, a detailed control will follow, and if necessary, the budget will be changed with the current funding for potentially needed increase in the budget.

After the approval of this stage of the project, the next step comes - preparation of the project documentation for building permission and tender documentation including technical specifications and final cost estimates and schedule. These final cost estimates should be processed as transparent as possible and the resulting value of the costs should not be deviated from the offers in the tender procedure of more than 10%. Bigger deviations should be analysed.

6 VALUE ENGINEERING

Value engineering is a system of interconnected specific procedures, knowledge and experience. In this way it is possible to find unnecessary costs of a particular project, i.e. those costs which do not increase usefulness, durability, quality, safety and other characteristics that are necessary for the implementation and subsequent proper use.

The goal of “value engineering” is to eliminate unnecessary costs and thereby to achieve lower project costs, without reducing functionality, safety, quality and other monitored properties of the project.

With “value engineering” or “value management” or “project reassessment” it is possible to find a balance between functionality, quality, safety and price of construction and subsequent maintenance. It is a way to keep costs within expected limits. It is a revision tool of already-designed construction in order to increase the value of the project by analysing the functionality/ specifications, and associated costs. This method is the most effective for complex or non-standard constructions and for constructions where previously validated standard elements cannot be used.

The basis of “value engineering” method is the following formula:

$$value = \frac{function}{cost}$$

where

value	…	lowest cost at which it is possible to achieve the desired properties *financial value in relevant currency*
function	…	minimum requirements for usefulness, durability, quality, security, etc. *expressed as a price in relevant currency*
costs	…	costs spent on the implementation of the project *financial value in relevant currency*

Two conclusions shown in the following diagram come from the above mentioned formula:

- Growth of costs significantly reduces the project value, unless there is an adequate increase in its function;
- In order to increase the project value, costs must be reduced without performance degradation.

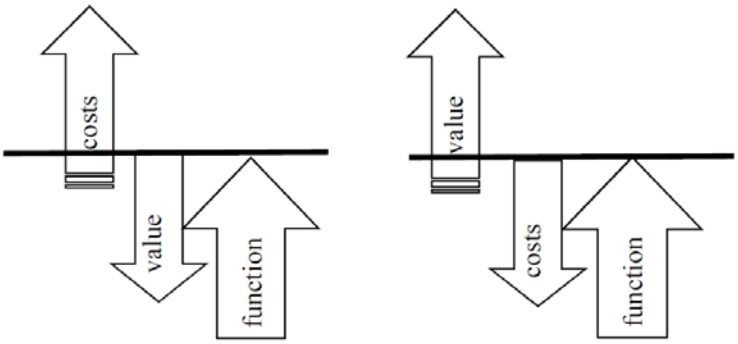

Figure 5: Links between changes in different parts of the formula.
Source: author

It is necessary:

- To use a systematic approach in which the elements of the system and the links between them will be analysed;
- To ensure systematic approach to solutions;
- To analyse the project by a team composed of experts who have relations to the topic.

The entire process of “value engineering” can be divided into several phases:

- Definition of objectives, identification of problems;
- Dealing with problems and proposal of measures;
- Evaluation of conclusions, selection of suitable alternatives.

Before starting the process of “value engineering” it is advisable to use functional analysis (FAST “Function Analysis System Technique”). During the analysis we determine the properties which the project proposal / logistics centre should have. After this analysis, or after determining project properties respectively, it is possible to design various solutions that will reduce costs.

“Value engineering” can be divided into two variants “A”, “B”, i.e. “before starting implementation” and “after starting implementation”:

However, variant “A” has a greater positive impact on the project - that is, before the start of the project. Although variant “B” will help to reduce costs, it cannot eliminate costs already incurred by the preparation of project documentation, etc.

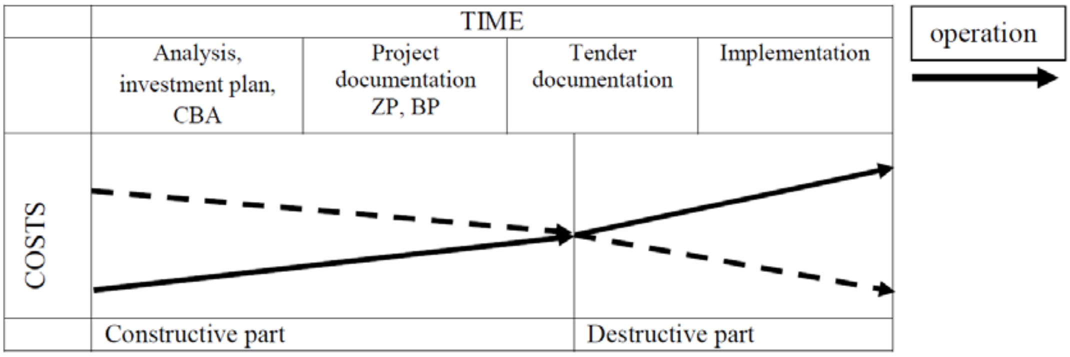

Figure 6: Costs for changes over time
***ZP = planning permission; BP = building permission**
Source: author

The figure above clearly shows that the final line at which you can significantly use the method of "value engineering" is tender, i.e. detailed, project documentation. At this stage, suggestions to changes can be applied without incurring higher costs.

There are two basic alternatives of Value engineering:

A. At the request of contracting authority - a team of experts will examine the prepared project documentation before processing tender documentation and before the start of tender for project contractors,
B. At the request of contractor, when after signing of a contract with supplier, this contractor comes with a proposal of acceptable savings for the client.

Alternative A) may be used if the project has been prepared for some time and some of the circumstances changed during the preparation of the project documentation. This situation occurs at transport projects very often because the preparation of projects takes several years due to its complexity.

At VE it is necessary to analyse written documents related to technical processes, technologies, specifications of tender documents, project administration, insurance, guarantees and contract draft between contracting authority and construction company.

This version of VE, which is usually carried out at request of contracting authority, is performed by a multidisciplinary group of experts from fields that relate to the topic. A tender should be prepared for processor of VE for each examined contract / project.

Alternative B) may be used in case this option is permitted in the tender documentation and financial conditions for contractors and investors, which depend on the amount of savings, are defined. The tender is held in standard form. Then contractor has the right to propose changes which will reduce the final price of the project implementation, and contractor is also involved in these savings to certain agreed percentage. Contracting authority has the right to accept or reject the proposal. The changes may relate to technological processes, materials, but always under the condition that they will respect the functionality, quality and security of the project. In some cases, proposed changes result in a change in building permission, and thus in a potential prolongation of completion date. It depends on contracting authority's agreement with contractor whether these changes will be accepted. But in large scale constructions the beginnings of each phase can be set so that the deadlines will be met.

The decision criteria whether to use the proposal or not should include the relation between the reimbursement for processing VE and percentage of price reduction of the contract in question and references and qualifications of the processor of VE.

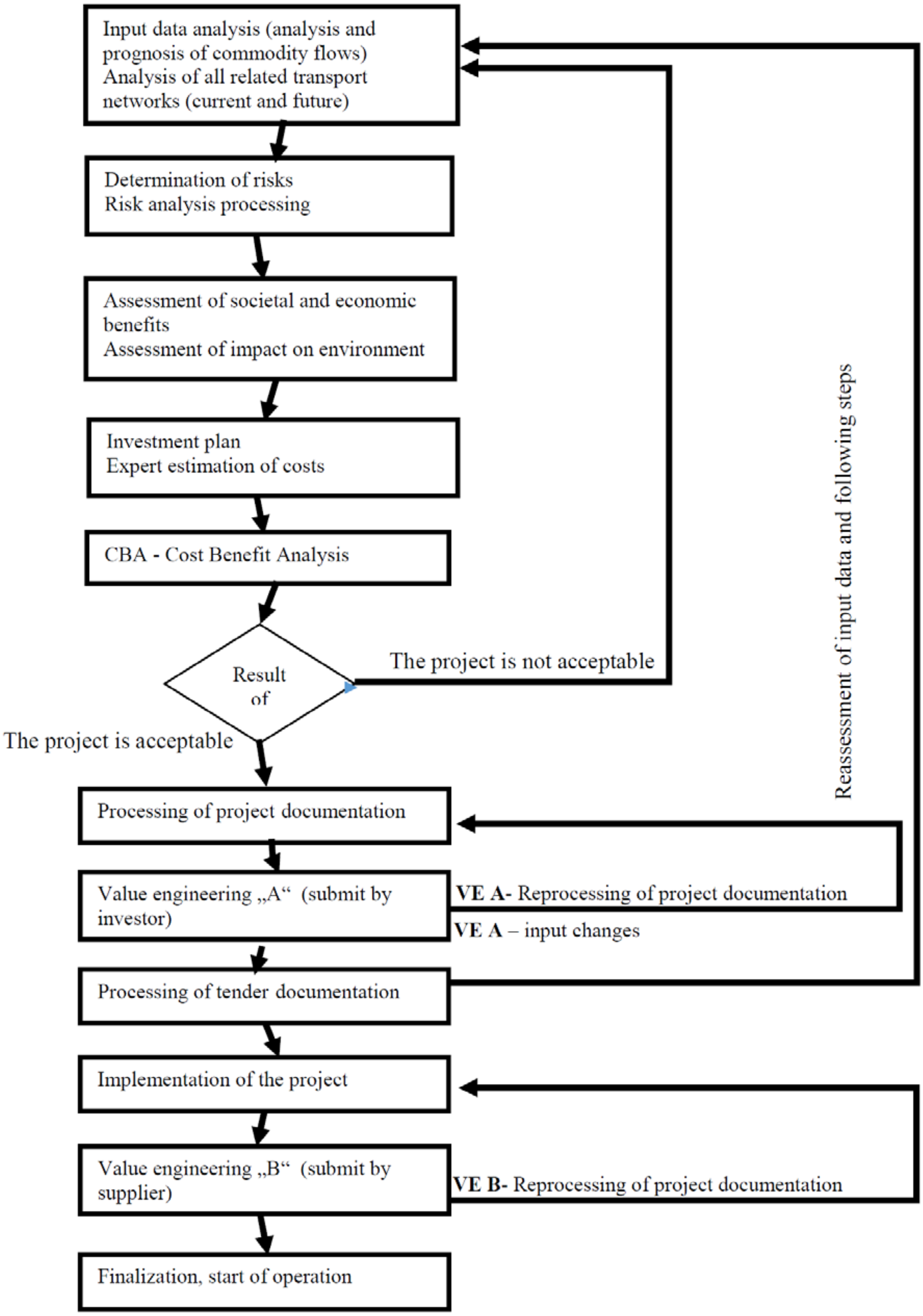

Figure 7: Diagram of project's preparation and implementation.
Source: author

7 CONCLUSION

Financial project management methodology allows to improve financial management in the design and implementation of a logistics centre, but is also applicable to all types of buildings. Once the final planning permission is issued, it is necessary to monitor the expected costs (based on the budget) of the project in the further course of the project. The deviation can be + -10% from the cost calculation in the project documentation for planning permission. In the case of exceeded deviation, it is necessary to perform detailed verification of eligibility of each item, and then provide potential higher implementation funds. In some cases, it may be also possible to reduce costs.

Using this methodology the re-evaluation of the project (Value Engineering - VE “A” VE “B”) may occur twice within the entire process.

An example of effective use of the “value engineering” method can be found in the USA, where public authorities are bound by law to use this method.

ACKNOWLEDGEMENT

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Effective Short-Term Energy Accumulation for Means of Transport

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ABSTRACT: This paper presents a new conceptual design of an efficient flywheel battery, designed from commercially available components. The basic idea is based on a possibility of using a spare wheel of a vehicle, or its steel or aluminium disc, as the gyroscope rotor at an early stage of rotor development. Even low rotation speeds accumulate sufficient amount of energy to accelerate a small vehicle in a city.

KEY WORDS: Flywheel battery, gyrobus, energy recuperation.

1 INTRODUCTION

For centuries, flywheels have been used in smooth running rotated mechanisms. Heavy rotation stone wheels served as flywheels in original purely mechanical powertrains. The Potter's wheel represents one of the ancient flywheels in the steam century, flywheels helped to overcome the dead body of a crank mechanism of steam engines by exploiting the stored kinetic energy. The flywheel currently forms an integral part of any combustion engine, in which it balances uneven rotations of the engine.

Unlike the initial very simple structures, flywheels have nowadays much more advanced designs to allow more complex functions (Lee et al., 2011; Plomer, 2010; Plomer, 2011; Yang, 2012). Thanks to that, flywheels are currently employed as short-term energy accumulators, whose energy can be reused later. In the future, applications are extensive and could include, e.g. hybrid and electric vehicles (Plomer, 2013), or voltage stabilization in electric distribution networks. The shape and design of the flywheel are optimized to store as much energy as possible. Materials from which the flywheels are constructed, e.g. as a combination of a heavy flywheel kernel and hardening of carbon fiber on the perimeter, are suitable even for very high-speed flywheels. In high-speed flywheels, a large amount of energy can be stored in a relatively low-weight flywheel. The importance of low-weight flywheels increases, especially for mobile applications including engines in vehicles.

In the past, the flywheel had been used as a source of energy for gyrobus drives, e.g. in Switzerland, Belgium, Congo, Sweden and China. A Swiss company Maschinenfabrik Oerlikon (ABB today) had 19 such gyrobuses in total. The gyrobus was connected to the supply of 500 Volts at each stop through three collectors placed on the roof of the vehicle. During the time necessary for changing passengers, the current from the power grid increased the speed of the flywheel through a three-phase asynchronous engine with a short anchor. The amount of energy accumulated in the flywheel was sufficient to cover a distance of several kilometers to a next stop, with an additional power supply pole. Moreover, during the acceleration of the gyrobus, the flywheel supplied the electric energy to the asynchronous traction engine. In case of sufficient slowdown of the gyrobus, the traction electric engine worked as a generator mode and supplied the energy back into the flywheel. This means that already at that time a part of braking energy was recovered.

On the other hand, due to the action of the gyroscope torque, the axes of rotation of heavy flywheels had to be vertical to minimize effects on driving properties of the vehicles. This often led to inconvenient designs of buses because the flywheel with an asynchronous motor was placed in the middle of the vehicle, which restricted a space for passengers.

Figure 1: Swiss gyrobus.

The revolutionary drive of the city transport vehicles mentioned above had several advantages over other means of public transportation. The first and foremost advantage was a zero-emission operation, because there was no internal combustion engine in the vehicle at all. Moreover, the vehicle in operation was substantially quieter. Another advantage was no need to build and maintain overhead contact lines between individual stops.

However, the design of the gyrobus from the 1950s had several disadvantages, in particular those stemming from a limited amount of materials that could be used for the design of the flywheel. Since a steel flywheel was used in the gyrobus, the maximum rotation speed was significantly limited and the requirement for a sufficient amount of energy storage was ensured by adequately large mass of the flywheel. Therefore, a total weight of the gyrobus increased significantly by the heavy flywheel and related safety demands were increased. Despite of limitation of the maximum flywheel speed - approximately at 3 000 1/min, a flywheel embedding was crucial due to its large mass. The flywheel was placed at a special chamber with decreased air pressure to reduce friction losses. The worse handling characteristics due to the higher weight and the gyroscope torque had negative effects on the turning ability, which represented another disadvantage of the gyrobus in comparison with diesel-powered busses.

Figure 2: APTS Phileas.

Gyrobuses from the 1950s have not spread due to many imperfections and their production was terminated. However, the idea of an easy usage of flywheel kinetic energy is alive and attracts current designers. A hybrid bus APTS Phileas from 2004 (Figure 2) can be mentioned as an example. This low-floor three-car bus combines an internal combustion engine, electric engine and flywheel of a power of 300 kW facilitating to store energy up to 4 kWh. The flywheel accumulates the energy derived exclusively from braking recovery. The accumulated energy can be used to drive the vehicle for a distance of approximately 3 km and the fuel saving of this hybrid system in comparison with conventional drives reaches up to 30%. Up to about 10% of this fuel saving is attributed to the flywheel itself. This paper aims to present a new design of a flywheel battery based on common components of vehicles, which allows effective accumulating of energy for later re-use for vehicle acceleration.

2 THE EXISTING APPLICATIONS OF FLYWHEEL BATTERY

Increasing demands on technical parameters of powertrains and, at the same time, needs to reduce energy consumption and contemporary re-usage of energy from renewable sources, have led to inventions of new technologies of flywheel batteries and their applications into new fields. In addition to the stationary flywheel batteries, mobile applications play an important role nowadays, e.g. in transportation. Mobility requirements have led to flywheel miniaturization in terms of its volume and weight.

Some examples are shown as follows:

- **Small flywheel systems for short-term voltage balancing in the power grid.** These systems have relatively small specific density, since the volume and weight are limited. On the other hand, a high specific output power can be achieved.
- **Usage of the flywheel to balance the peak voltage of electric vehicles.** The aim is to reduce significantly high currents from the original battery power for the traction engine. The battery life is significantly prolonged by reducing the peak current.
- **Wind-diesel generator with flywheel battery.** At the beginning of the 21st century, the wind-diesel power station with a kinetic energy accumulator was designed. Diesel generator and flywheel compensate wind oscillations. Thanks to the flywheel implementation, the wind unit is able to deliver high power within a period of almost 2 minutes.

- **Flywheel for photovoltaic systems.** Incorporating flywheels into a photovoltaic system, the extension of the energy supply up to approximately 30% can be achieved.
- **Flywheel in the power grid.** Flywheels with large capacity around 10MJ can be implemented in the power grid, which results in the increase of the network quality. This system is able to stabilize voltage in the power grid with minimal tolerance for more than 10 minutes.
- **High-power-UPS device.** By combining several tens of flywheel batteries, a high-power-UPS device can be built. Delivery of a sufficient amount of energy for experiments with plasma, acceleration of heavy materials and super-large UPS systems, represent potential examples. The maximum power of around 50MW can be delivered from the UPS devices for more than 10 seconds, with overall efficiency exceeding 90%. Similar flywheels have been tested for city buses and rail vehicles with savings up to several tens of percent.
- **Applications in aerospace industry.** Flywheel battery can replace or complement the standard batteries in some applications in on-board systems which results in considerable savings in weight and total volume of battery systems.

3 ENERGY STORAGE IN FLYWHEELS

Advances in material technology, magnetic bearings and power electronics have led to successful applications of flywheels in a short-term storage of energy. Modern flywheels work with high power and thanks to the composite materials, the flywheels reach high angular speed with power density higher than is the power of chemical batteries. Exploiting magnetic bearings significantly reduces internal losses (Kamf, 2012). Since the accumulated energy is proportional to the square of the speed and only linearly to the flywheel mass, the high-speed flywheel rotation is essential for accumulating a large amount of energy.

The benefits of flywheel applications (Bolund et al., 2007) for energy accumulation stems from basic properties of the flywheels, namely from:

- High power density;
- High energy density;
- Capacity of being independent of the depth of discharge and the number of charging cycles;
- Simple measurability of a charge status, which is given simply by the angular speed of the flywheel;
- Very short charging period;
- Very low maintenance requirements during flywheel operation.

One of the most important advantages of flywheels is their ability to handle high-level power. This property is required for example in vehicles if a high power is needed during vehicle acceleration. On the contrary, if a traction electric engine is used in the generator mode as a brake, the braking of the vehicle generates a large amount of energy in a short time interval and the breaking energy can be accumulated in the flywheel battery. It is evident that in such regime, energy is used more efficiently, which results in reducing fuel consumption and thus also in reducing CO_2 emissions.

In principle, flywheels store energy into a rotating mass. The amount of stored energy depends on the weight and rotation speed of the flywheel. The recent flywheel designs place the rotating mass into vacuum, where the friction losses during extremely high revolutions of the rotor are reduced. An electric engine, which stores kinetic energy in the flywheel, can work in the reverse mode as a generator in case that energy from the flywheel battery can be exploited.

The main purpose of the flywheel battery is the short term energy accumulation in the flywheel rotor for its later usage. Not only the shape of the rotor is important for the amount of the accumulated energy, but it is also the material from which the rotor is constructed. These parameters have a restrictive effect on the maximum stored energy that can be accumulated in the flywheel. This limitation stems, in particular, from the strength of the materials and also from characteristics of bearings used.

Modern flywheels usually consist of aluminium core that is coated with high-strength composite material. The composite acts as the main energy accumulator in the flywheel and temporarily at high speeds ensures the stability of the rotor as a whole, particularly if the rotational speeds exceed the aluminium-core strength limits. On the other hand, orthotropy of the composite materials causes complications in the flywheel design. In addition, the properties of the composite materials largely depend on the orientation of the fibres.

4 HIGH-SPEED FLYWHEEL BATTERY

Due to the dependence of the amount of the stored energy in a rotating mass on the square of the angular velocity, the highest possible angular velocities of the rotor in the flywheel battery are required. However, high rotational speeds greatly increase technical demands on the material properties of the rotor, the bearings and, last but not least, also on decreasing of the additional resistance acting on the rotating flywheel.

The amount of kinetic energy of a rotating mass is described by the basic equation:

$$E_k = \frac{1}{2} J\omega^2.$$

Moment of inertia (J) depends strongly on a shape of the rotating mass and its weight. The principal shapes of steel rotors are full cylinders, for which the following equation is relevant:

$$J = \frac{1}{2} m r^2 = \frac{1}{2} \pi a \rho r^4,$$

where r is radius, a is length of cylinder, m is weight and ρ is cylinder density.

The hollow cylinder is another frequently used shape of the flywheel rotor, for which holds

$$J = \frac{1}{4} m (r_0^2 + r_i^2) = \frac{1}{4} \pi a \rho (r_0^4 - r_i^4).$$

It is evident from the equations above that achieving the highest angular speeds is decisive for storing the maximum amount of energy in flywheels.

On the other hand, there are limitations resulting from the material strength σ. Materials with low density and high strength are optimal for constructing flywheels.

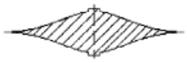
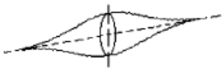
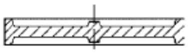
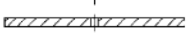
The maximum energy density with regard to flywheel volume and weight is

$$e_v = K_\sigma, e_m = K_\rho^\sigma,$$

where e_v and e_m are specific kinetic energy per units of volume and mass, and K is the shape coefficient, σ is the maximum strength of the (rotor) flywheel, and ρ is the density of the material.

Taking into account plane stress and assuming the height of the disc is relative to its diameter, the shape coefficient K can be specified for homogeneous isotropic material with Poisson number 0.3 according to Table 1.

Table 1: Shape factor K in dependence of rotor cross-section (Bolund et al., 2007).

Fly wheel geometry	Cross section	Shape factor K
Disc		1.000
Modified constant stress disc		0.931
Conical disc		0.806
Flat unpierced disc		0.606
Thin firm		0.500
Shaped bar		0.500
Rim with web		0.400
Single bar		0.333
Flat pierced bar		0.305

Three-dimensional interaction of tension exists in a three-dimensional body. For a rotor designed from non-isotropic materials, such as that formed by fiber-reinforced composites, three-dimensional interaction of tension will represent the limiting factor for realistic dimensions of the flywheel. Taking into consideration the security aspects, the hollow cylinder, in which the three-dimensional effects are minimized, is the basic shape. The radial and axial tensions dominate in the low-shape flywheels.

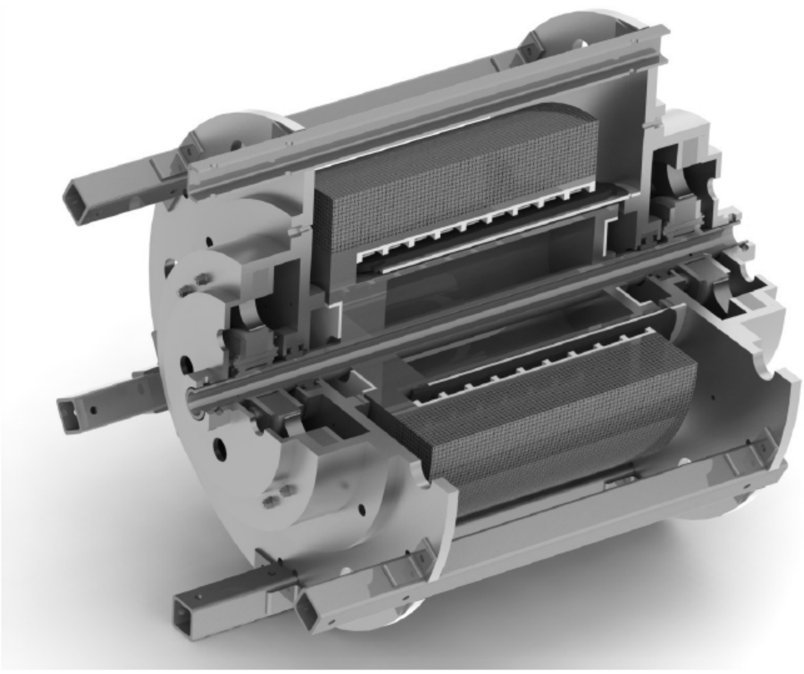


Figure 3: A cross-section of a potential high-speed flywheel battery design.

From a technical point of view, there are no obstacles to design the high-speed flywheel battery (e.g. Tang et al., 2012). However, from an economic point of view, it is impossible to implement such designs into a serial production and apply them in a broad scale into common cars at present.

5 NEW DESIGN OF ADDITIONAL FLYWHEEL BATTERY USING COMMONLY AVAILABLE COMPONENTS

This paper aims to present a conceptual design of an efficient flywheel battery, designed with commercially available components. The design not only considers the flywheell rotor itself, but also its housing in a vehicle without additional extensive modifications. The basic idea is based on a possibility of using a spare wheel of a vehicle, or its steel or aluminium disc, as the gyroscope rotor at an early stage of rotor development.

We present an estimate of an amount of kinetic energy stored in a standard aluminium rotating disc, for which we consider technical parameters of the Crateris disc of Skoda Auto company, with diameter of 16", mass = 9.73 kg, and the moment of inertia $J = 0.28\ kg.m^2$. These parameters are suitable for tyres 205/55 R16, with dynamic radius of approximately r = 0.3 m. The aluminium disc is designed for maximum vehicle speeds, often exceeding 250 km/h. Speed (v) of the rotating disc, while the vehicle is moving, and its respective angular velocity, are linked according to the formula $v = \omega \times r$, where r is radius of the disc. The estimated values of angular velocities in dependence on a vehicle speed are presented in Table 2.

Table 2: Estimates of disc velocities.

Vehicle speed (km/h)	100	125	150	175	200	225	250	275	300
Angular velocity (1/s)	92.6	115.7	138.9	162.0	185.2	208.3	231.5	254.6	277.8
Revolutions (1/min)	884	1105	1326	1547	1768	1989	2210	2432	2653

Wheel angular velocity, or speed of aluminium disc respectively, at high vehicle speeds are considerable high and hence a relatively large amount of energy can be stored in the rotating mass.

The amount of stored kinetic energy $E_k(J)$ can be calculated from the equation:

$$E_k = \frac{1}{2} J \omega^2,$$

Where $J\ (kg.m^2)$ is moment of inertia and $\omega\ (rad.s^{-1})$ is angular velocity of the rotating mass.

Similarly to Table 2 and based on the speed of rotation, we estimate the amount of the stored kinetic energy (Table 3).

Table 3: Estimates of amount of stored kinetic energy in kJ.

Angular velocity (1/s)	92.6	115.7	138.9	162.0	185.2	208.3	231.5	254.6	277.8
Angular velocity (rad/s)	582	727	873	1018	1164	1309	1454	1600	1745
Kinetic energy (kJ)	47.4	74.0	106.6	145.1	189.5	239.9	296.2	358.3	426.5

It is necessary to use the angular velocity ω for the equation of kinetic energy (J) in the units $rad.s^{-1}$. The angular velocity can be recalculated according to the formula $rad.s^{-1} = \frac{\pi}{180} \times s^{-1} \times 360°$.

Table 4: Estimates of amount of stored kinetic energy in Wh, kWmin and kW10sec.

Disc revolutions (1/min)	884	1105	1326	1547	1768	1989	2210	2432	2653
Kinetic energy (kJ)	47.4	74.0	106.6	145.1	189.5	239.9	296.2	358.3	426.5
Kinetic energy (Wh)	13.2	20.6	29.6	40.3	52.6	66.6	82.3	99.5	118.5
Kinetic energy (kWmin)	0.8	1.2	1.8	2.4	3.2	4.0	4.9	6.0	7.1
Kinetic energy (kW10sec)	4.7	7.4	10.7	14.5	19.0	24.0	29.6	35.8	42.6

It is evident from the calculated values of kinetic energy that the accumulated amount of energy is sufficient for an acceleration of a vehicle to approximately 50 km/h solely by exploiting the accumulated energy. This becomes important particularly in urban areas. However, the main benefit of this flywheel battery is its ability to support the combustion engine in situations requiring a sudden high power supply from the combustion engine. Thus in such model modes, the combustion engine can run in economical mode and the flywheel can be used for a short-term demand of increased power for the vehicle acceleration.

The flywheel battery has been applied in the Formula 1 championship, which is often regarded as a pioneer of innovative technologies. However, the innovations used originally in the Formula 1 were at that time very expensive for serial production. From technical point of view, the efficiency of the innovations was proved and later such innovative batteries were incorporated into common cars. Thanks to large production, the cost of the battery production could be significantly reduced.

The flywheel battery in the Formula 1, known as system KERS (Kinetic Energy Recovery System), allowed maximum power of 60 kW for 6.67 seconds in the racing season 2009. The weight of the rotor of 5 kg, revolution speed up to 60 000 1/min and the accumulated energy resulted in approximately 110 Wh. Total weight of system KERS was 24 kg. The accumulated energy in the presented design of the additional flywheel battery with the use of the aluminium disc is comparable with the energy stored in system KERS. Unlike in the Formula 1, a small increase in common vehicle weight, due to adding the battery comprising the rotor, does not mean any obstacle for common cars.

Particular design of an additional flywheel battery will depend on vehicle specifications. Fixing the rotor flywheel in a vehicle, which can be in the simplest case the aluminium disc, is assumed to be identical to the fixing used for mounting wheels on vehicle. Therefore, using of standard holes and screws is expected. The disc itself will be fixed to the flange of the rotor of the electric engine. The choice of electric engine, of a standard production on the market, depends on parameters of the flywheel battery. Speed up to 5 000 1/min and storage of the short-term maximum power up to 40 kW for a few seconds are assumed which are commonly used in hybrid transmissions (ZF 8P automatic transmission).

To store the energy in a flywheel battery for several minutes, it is necessary to eliminate losses, due to an air resistance acting during the high-speed disc rotation. This can be effectively achieved by placing the flywheel battery in an airtight vacuumed container. Then, the resistive forces are significantly reduced and energy storage in the flywheel battery will be very effective.

The design assumes the flywheel battery could be also connected to a standard 230 V outlet. Such configuration allows a quick recovery charging of the flywheel battery with a smaller amount of energy. The charging will be sufficient to start the combustion engine in case that the main vehicle battery operating at voltage of 12 V would not have sufficient amount of energy. Moreover, disconnecting of the standard 12 V main battery in dependence on the current situation is assumed. The energy required for the on-board vehicle systems will be delivered solely from the flywheel battery that increases the lifetime of a standard main 12 V battery in the vehicle.

An alternative to the above described conceptual design of the flywheel battery using the common aluminium disc could be its replacement with a high-strength steel disc, whose shape is optimized for the maximum strength. Other components of the flywheel battery, e.g. the electric engine, can be used without a change, providing the electric engine will allow higher speeds of the high-strength steel-disc rotor.

6 CONCLUSION

Significant requirements concern balancing of any rotating mass, including the rotor of a flywheel battery. Even small imprecisions in the mass balancing can cause additional forces acting on rotor bearings, causing vibrations and, in extreme cases, even a failure of the entire system.

Therefore, attention has to be paid to a correct balancing of the flywheel rotor. It is quite logical to exploit the same system of balancing for the rotating aluminium disc, which is used in the complete vehicle wheels. The small stick-on counter-weights can be added to peripheral parts of the aluminium disc. This commonly used technique is sufficient for the additional flywheel battery designed in Chapter 5.

There are also other possibilities of rotor balancing, which are less common. Spontaneous balancing balls (granule powder) rotating together with the flywheel rotor on its inner side can be used as an example. This method, in which polymer granulates were applied into truck tyres, was invented in the 1990s in the USA. By this method, driving properties improved and tyre wearing was reduced into area of its contact with a road. Later, other balancing techniques, based on powder, derived from silica sand, porcelain and small glass balls, were invented. The principles of this kind of balancing are simple. Uneven radial forces act during the rotation of a tyre. Small balls permanently move to places with the lowest radial forces and thus balance differences among them. Usage of the same granule-powder truck-tyre balancing system is also convenient for balancing the flywheel battery. The amount of the granule powder must be adjusted according to the weight of a flywheel rotor. Another possibility is to use small steel spheres with a diameter of approximately 6 mm for self-balancing.

The presented new design of the additional flywheel battery, constructed predominantly from commonly available components of vehicles, shows a promising technical solution of an additional energy-storage system for common vehicles, which are usually equipped with a spare wheel. At present, cars become frequently equipped with adhesive sets to repair tyres after a puncture, instead of having a spare wheel. Thus the space for the spare wheel, usually under the luggage space, remains unused. Therefore, using this space for the proposed additional flywheel battery is a challenge. Moreover, the presented new design does not require any demanding specific development, including e.g. a production of a carbon-fibre rotor. In general, high-tech development would increase several times the rotational speed and the amount of stored energy, but from the economic point of view, such solution would have limitations in its wider distribution. Modern trends in technologies emphasize reducing both energy demands, as well as decreasing emissions from the means of transport. Therefore, the designed flywheel battery may be a new perspective short-term energy storage system. Extensive expansion of such flywheel battery does not seem to be limited by any major technological or economic barriers.

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Technical Note on Recent Developments in Road Safety

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ABSTRACT: The main objective of the paper is to bring a short overview of road safety activities discussed during the 2014 Transportation Research Board Annual Meeting in Washington, D.C. Basic information about the issue of road safety and the list of the committees with short comments will be followed by information about actual topics discussed on the committees' meetings and sessions. The last part of this technical notes deals with the research priorities identified in the TRB 2014 meeting.

KEY WORDS: TRB, road safety, priorities, safety management, strategy.

1 ROAD SAFETY RESEARCH AT TRB

The 93rd TRB Annual Meeting in Washington, D.C. was held at the beginning of this year. The Transportation Research Board of the National Academies meeting is considered to be the largest world conference on transport. This year the annual meeting brought together almost 12 000 professionals from the transport field, 2 500 of them arriving from different continents. The programme of the meeting offered more than 4 500 presentations in nearly 800 sessions and workshops focused on a wide range of transport related issues.

The issue of safety (road safety) can be considered as one of the pillars issues of TRB activities. With more than 200 committees, almost every transport mode and topic is represented in the standing committee structure. The Standing Committees are divided by topic as follows:

- Design and Construction;
- Operation and Preservation;
- Planning and Environment;
- Policy and Organization;
- Safety, System components, and Users.

Safety is a multidisciplinary issue which should also be reflected in other committees and subcommittees. Approximately 82 committees have safety directly in the name of the committee, and approximately 20 committees are related to the issue of road safety. Some of the road safety oriented committees with description of their scope will be shortly mentioned in the following text.

Standing Committee on Transportation Safety Management
The mission of the TRB Committee on Transportation Safety Management is to promote and support research to advance road safety by focusing on cross-cultural, multidisciplinary safety management system improvements throughout the safety decision-making culture. The areas of concern include: 1) the advancement of safety management systems, 2) research and technology to improve safety, and 3) models of safety delivery systems.

The goal is to proactively manage the transport safety research process and stimulate and disseminate exemplary research to promote transparent and accountable cross-cultural multidisciplinary transport. At the moment, it consists of the following subcommittees:

- Toward Zero Deaths;
- Global Road Safety;
- School Transportation;
- EMS Safety;
- Transportation Safety Planning;
- Roadway Safety Culture;
- Rural Road Safety.

Among other relevant committee can be count also:

- **Standing Committee on Roadside Safety Design;**
- **Standing Committee on Transportation Safety IDEA Program Committee;**
- **Standing Committee on Traffic Law Enforcement;**
- **Standing Committee on Truck and Bus Safety.**

The commercial programmes, sponsored by different commercial sponsors are also provided under TRB. As an example from the road safety oriented programme, the following programme can be mentioned.

Commercial Truck and Bus Safety Synthesis Program
Linkage and close cooperation among the committees are also arranged on the basis of the section system, e.g. **Safety and Systems Users Group** (AN000).

The Safety Section is part of the System Users Group. It consists of nine committees and two task forces that propose research, share research findings, sponsor special activities, and provide a forum for transportation professionals to discuss today's and tomorrow's safety-related transport issues. The chairs of each of these committees are members of the Safety Section Executive Board, who along with the section chair, provide general oversight of the activities within the Section (https://www.mytrb.org/CommitteeDetails.aspx?CMTID=3204).

2 RECENT THEME IN ROAD TRAFFIC SAFETY AND MANAGEMENT

A number of research topics and the current topics of different subcommittees identified as potential future research topics were discussed at the 2014 TRB Annual Meeting.

One of the main topics mentioned on the meeting of **Transportation Safety Management Committee** (Robert E. Hull, Utah Department of Transportation, presiding Jake Kononov), was how to continue with planning using AASHTO (AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS). It was discovered that the process now is too standardized and fails to react sufficiently to safety demand. Some of the important issues were defined for the following work of the subcommittees:

- Are reconstruction and new construction the same?
- Does the concept of design speed apply in all contexts?
- Are there important interactive effects of geometric elements on safety performance?
- How well do our design models and standards reflect knowledge of safety performance?
- Do any of our design standard models (nominal safety) require revision?

Very important information, especially for European partners involved in PIARC activities, is the decision of TRB to closely cooperate with PIARC Technical committee 3.1 National Road Safety Policies and Programmes, and generally all relevant TC of PIARC.

The main topic of the **Traffic Law Enforcement Committee** (Keith D. Williams, Federal Highway Administration, presiding) is a legal responsibility of special vehicles (Segway, etc.) and legal responsibility of driver, vehicle (car producer) with a different automatic driving assistant system.

Actual topic in the Czech Republic was also discussed on the session **Speed Monitoring, Traffic Calming, and GIS Applications for Law Enforcement Agencies, Researchers, and Engineers**. The following presentations should be mentioned, i.e. *Methodological Approach to Spatiotemporal Optimization of Rural Freeway Enforcement in Florida* (Carrick et al., 2014).

The presentation *Threshold Effects of Speed Monitoring Devices on Driver Speeding Behavior* (De Leonardis et al., 2014), also brings some knowledge on the current issue.

In the **Transportation Safety Planning Subcommittee** (Edward Ronald Stollof, Institute of Transportation Engineers, presiding), and *MPO Safety Initiatives (A New Jersey Perspective)* (Kaplan & Marandino, 2014), the authors found out that aggressive driving was a contributing factor for 50% of annual traffic fatalities in the Delaware Valley on average, (data collected from 2008 to 2010). Other crucial information is that seven factor contribute to 95% of regional fatalities in New Jersey.

Saving the World: Overview of Road Safety Initiatives Around the Globe (Jennifer Harper Ogle, Clemson University, presiding). *Transferability of New Highway Safety Manual Freeway Model to Italian Motorway Network* (La Torre et al., 2014). The main message of this session is to deal with the relevance of Prediction Road Accident Models. Safety prediction methodology and analysis tool for freeway and interchanges will be incorporated in to the HSM.

Analytical Models for Safe and Sustainable Transport (Qin, X., 2014), *Data Mining and Complex Network Algorithms for Traffic Accident Analysis* (Lin et al., 2014). And also next interesting presentation should be mentioned, *Comparison of Sichel and Negative Binomial Models in Hotspot Identification* (Wu et al., 2014).

The above mentioned topics are also relevant for European countries, as they are also discussed at meetings and workshops of FEHRL, FERSI, ECTRI, ETSC and TRA conference, etc. The summary of a new research topic is generally presented on the web sites of each committee or in feature papers, e.g. Overview of Truck & Bus, Safety Research Needs.

Transportation Research Board (TRB), Truck & Bus Safety Committee (ANB70), April 3, 2014. The recommended topics are sent to the main council meeting after committee voting. The process of discussion, drafting proposal, committee decision, final approval, financing and implementation can be followed on the TRB web site http://rns.trb.org/. An example of one of the proposed projects can be seen in the above mentioned sites in Subject Category: Safety and Human Factors: Determining and Communicating Reliability of Crash Prediction Models, Committee: AFB10, Geometric Design, Date Posted: 9 January 2014, Date Modified: 28 January 2014.

3 CONCLUSION

The 93rd Transportation Research Board Annual Meeting was a very well organized conference on a high professional level with unique opportunity to meet professionals from almost all the world, share new pieces of knowledge, make new contacts and partners, and discuss new projects and activities.

A similar activity as TRB – TRA (Transport Research Arena) can be mentioned at the European level. It started in 2006 in Gothenburg and it is held regularly every two years. TRA has gradually become a major conference on transport in Europe. The first conferences were exclusively focused on road transport; the last events already cover all transport modes and transport related issues. TRA is supported by the European Commission, the Conference of European Road Directors, and by three European Technology Platforms: the European Road Transport Research Advisory Council (ERTRAC), the European Rail Research Advisory Council (ERRAC), and the WATERBORNE.

The International Transport Forum (ITF) is an inter-governmental organisation within the OECD (Organisation for Economic Co-operation and Development) system. It acts as a think tank for global transport policy issues and organises an annual summit of transport ministers. Before 2007, the International Transport Forum existed for over 50 years as the European Conference of Ministers of Transport (http://en.wikipedia.org/wiki/International_Transport_Forum).

From the point of view of the Czech Republic we can consider the international research cooperation in the field of road safety sufficient, also thanks to Centrum dopravního výzkumu activities in the TRB, FERSI, ECTRI, FEHRL, HUMANIST, ETSC etc. Although the Czech Republic is still facing challenges in road safety issues, comparing to Central European countries or more developed countries in the world, we are still missing a system for systematic financing of applied research in the field of transport and especially in road safety.

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Technical Note on Recent Developments in Travel Behaviour Analysis

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ABSTRACT: The main objective of the paper is to present recent developments in travel behaviour analysis that appeared at the 2014 Transportation Research Board Annual Meeting in Washington, D.C. The technical note is conceived as a brief review of key presentations and posters dealing with innovative methods in the collection of travel behaviour data, particularly with topics of technological advances in travel behaviour surveys.

KEY WORDS: travel behaviour analysis, travel survey methods, GPS, TRB.

1 TRAVEL BEHAVIOUR RESEARCH AT TRB

TRB Annual Meeting in Washington, D.C. organized by Transportation Research Board of the National Academies is considered to be the largest world conference on transport. The latest annual meeting brought together nearly 12 000 transport professionals, who could choose from more than 4 500 presentations in nearly 800 sessions and workshops focused on a wide range of transport related issues.

The theme of travel behaviour has been in the focus of the Transportation Research Board since its formation in 1973. The Committee on Traveler Behavior and Values started with the promotion of research in the field of disaggregate demand modelling and behavioural models of travel demand. The committee was soon recognized as one of the most progressive and attractive among TRB committees in the sense of the number of papers submitted for each annual meeting (Stopher, 2012). This led to the formation of numerous subcommittees within which some became later full-fledged committees (e.g. survey methods subcommittee). Judging according to the number of papers submitted to TRB and the number of attendants at the committee meetings, the Committee on Traveler Behavior and Values remains, together with the Committee on Transportation Demand Forecasting, one of the most active committees within the TRB Section on Travel Analysis Methods. However, it should be mentioned that the research on travel behaviour still finds substantial support in activities of the Travel Survey Methods Committee and its subcommittees, particularly Household Travel Survey Subcommittee, New Technologies Subcommittee and Stated Response Surveys Subcommittee.

At the 2014 TRB Annual Meeting there were four hot topics that reflected recent technological developments and/or indicated actual need for more intensive research – automated vehicles, big data, extreme weather events and performance management. In the following sections we will focus particularly on the second topic – big data – that seems to be the most relevant for travel behaviour research.

2 RECENT ADVANCEMENTS IN TRAVEL BEHAVIOUR SURVEY METHODS

Travel behaviour surveys have remained for more than 50 years the main source of data for transport planning. Traditional surveys administered in countries all around the world still rely on well tested methods of personal interviews, survey sampling and statistical inference. However, the problem of decreasing response rate (Atrostic & Burt, 1999) gives rise to doubts about their representativeness. Moreover, several studies showed that traditional approaches to travel surveys suffer from inaccuracies caused by limited abilities of respondents to recall details of their trips (Stopher et al., 2007) or errors done while filling in the questionnaire (Golob & Meurs, 1986).

First attempts to solve above mentioned deficiencies in travel behaviour surveys came along with wider spread of GPS based tracking devices (Guo & Poling, 1995; Murakami & Wagner, 1999) and GSM technologies (Draijer et al., 2000) in the late 1990s. Soon, GPS devices started to be used as a complement to ongoing traditional regional surveys (Bricka & Bhat, 2006) and their pilot use appeared also in national travel surveys in the UK and France (Rofique et al., 2011; Marchal & Pham, 2013). These studies confirmed that even passive tracking can significantly improve precision of time and spatial attributes of trips. On the other hand, it was also shown that the problem with a reliable mode and trip purpose classification still remains the main shortcoming of passive GPS tracking.

Unceasing interest in improvements of technology assisted passive travel surveys is also motivated by increasing occurrance of smartphones that are equipped with GPS and other sensors, and yet more and more frequent willingness of mobile phone operators to collaborate in research related to the use of residual GSM data stored in their data warehouses. Growing interest in the use of GPS devices in travel related surveys is also obvious in the number of papers submitted to TRB Annual Meeting. In 2010, 6.46% of papers presented at the TRB meeting contained words “GPS” and “survey”, while in 2014 the number of such papers grew up to 7.77%, which corresponds with 20% increase. Research areas related to the use of GPS in travel surveys can be clustered into four groups – practical experience from data collection, data processing and data use. In the following text we will look closer at recent TRB papers related to each of these topics.

Practical experience from data collection using smartphones were presented in the paper titled “A Smartphone-based Travel Suvey Trial Conducted in Kumamoto, Japan: An Examination of Voluntary Participants’ Attributes” (Maruyama et al., 2014). The authors focus on one of the most critical aspects of passive travel behaviour surveys – low response rate and sample representativeness. Only 97 participants out of 13 279 households selected for the survey agreed to participate. Although other studies found that the willingness to participate in GPS surveys is lower compared to traditional surveys using PAPI, CAPI or CATI methods, the response rate lower than 1% is unique. The authors compare descriptive statistics of the sample with descriptive statistics of respondents in a parallel PAPI survey and characteristics of the population to show that the sample structure is far from being representative, especially regarding the following attributes: age and gender. This finding confirms the need for deeper understanding of processes underlying low response rate and low representativeness of samples in passive travel behaviour surveys.

A closer look on motivation to participate in smartphone based survey was presented in the paper “Considering smartphones: User attitudes towards privacy and trust in location-aware applications” (Cottrill, 2014). The author shows that concerns about location privacy depend on the type of application used. The degree of trust concerns noted by the application users is the highest in case of transport related applications. On the other hand, social networking and mobile commerce application face a significantly lower degree of trust. The users also state that they do not trust application developers and administrators when they say that they are not selling their data or that they are not providing them to the government. She concludes that wider acceptance of passive tracking technologies may be enhanced “by developing of transparent and open models of data access, sharing, storage and use”.

Data processing topic was covered by two papers that focused on the same issue – identification of trip attributes (transport mode and trip purpose) from GPS data. Feng and Timmermans (2014) compare seven classification algorithms for detection of a transport mode. The authors show that even a relatively small set of attribute variables (e.g. speed, distance to infrastructure, quality of GPS signal, transport mode ownership) can be used for precise classification of transport mode, and that selection of proper attributes may be more important than the choice of a classification method.

Oliviera et al. (2014) compares two methods for classification of trip purpose, which is, comparing to transport mode classification, much more data demanding. The paper shows that procedures presented in the paper can lead to overall classification accuracy higher than 70% across all trip purposes and around 90% for the most common mandatory activities – work and school. These results confirm the increasing trend in accuracy of trip purpose classification algorithms. The authors also suggest several topics for further research that may bring these procedures closer to practitioners.

The topic of **data use** was presented by four papers. Alesiani et al. (2014) presented a disaggregate model of travel demand derived from publicly available data from communication and social networks. Wang et al. (2014) and Iqbal et al. (2014) presented potentials use of mobile phone data in travel behaviour studies, resp. for estimation of origin destination matrices that can be utilised for example for transport model validation. Finally, Hess et al. (2014) presented a methodically precise study on the use of GPS data for the estimation of route choice models for heavy goods vehicles.

3 CONCLUSION

2014 TRB Annual Meeting confirmed the trend in the use of big data for transport planning. This technical note provided a review of studies related to the use of big data, specifically mobile phone data, in travel behaviour analysis. It can be concluded that although there are still many issues to be solved, the day of a wider use of big data is closer year by year.

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