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CONSTRUCTION OF THE URBAN PUBLIC TRANSPORT SYSTEM'S QUALITY INDICATOR WITH MISSING DATA

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The purpose of this investigation is the development of transport system's quality indicator – UPTQI (urban public transport quality indicator) calculation methods where some values are missing in the data set. As a quality indicator, the indicator accumulating the information about urban public transport system – composite indicator is used. The algorithm described in [1] has been used for developing the composite indicator. The special accent is made on a choice of a missing data imputation method in an initial data set and on stability of results. It is not possible to make the unequivocal recommendation for use concrete method in the presence of a large number of offered methods. In many respects it depends on the initial data. The initial data concerning the cities of Europe were taken from EUROSTAT database [2]. The 8 sub-indicators for 2006 have been used for constructing the UPTQI.

The research was divided into three stages. At first, artificial missing data was introduced, and investigated the influence of the 3 selected methods of missed data substitution (unconditional mean imputation, imputation by median and clustering-based imputation) upon the results of composite indicator calculation. In the next stage the cities with the missing data have been added (in total 62 European cities). The method which is chosen as the best for this problem during the first stage has been used to the missing data imputation. To calculate the weights and to aggregate the same variants of algorithm, as at the first stage were used. At the last the results of UPTQI constructing were analysed for uniformity.

Keywords: public transport, quality, composite indicator, weights, missing data, imputation

1. Introduction

The purpose of public transport is rendering safe, reliable, punctual, accessible, non-polluting and cost-effective transport services to people. So, there are many characteristics, which need to be measured for understanding the actual quality of public transport system, and it is difficult to estimate the actual situation on the basis of this multivariate set of data. The benchmarking of the urban public transport can apply a scalar integral or composite indicator to be constructed – instead of using a set of initial characteristics as a basis. Indicator is an integral performance index presenting a complex estimate of a process, system, or object. A multivariate set of sub-indicators forms a basis of developing the integral indicator which is transformed into a scalar in a certain way.

The integral (composite) indicator is a function from sub-indicators and weights as follows:

$$CI_i^t = f(x_{i,1}^t, x_{i,2}^t, \ldots x_{i,m}^t, w_1, w_2, \ldots, w_m), \quad (1)$$

where CI_i^t – value of indicator for object i ($i = 1 \ldots n$) at time t,

$x_{i,j}^t$ – value of sub-indicator j ($j = 1 \ldots m$) for object i at time t,

w_j – weight associated with sub-indicator j ($j = 1 \ldots m$).

The most important advantages of composite indicator in the scalar form are a possibility of using it successfully for comparison and development analysis instead of a multivariate set of parameters. The European Plan of Research in Official Statistics (EPROS) for 2007–2013 singles out the continuation of work in the field of composite indicators and applying statistical methods in developing them as one of the top priorities.

There is the attempt to construct a composite indicator of urban public transport quality indicator – UPTQI, provided for by urban public transport system (UPTS) in the work.

One of the essential problems arising when UPTS quality is assessed is the missing data problem. The approaches to missing values imputation can be subdivided into two groups: Single imputation (Implicit modelling – Unconditional mean/median/mode imputation, Regression imputation, Expectation Maximisation imputation; Explicit modelling) and Multiple imputation. As there are no universal recommendations for usage of this or that method of the imputation of the missing data and results of its usage depend on character of a solved problem, on a set of variables, and on model of skips. In order to choose the imputation method, first of all we will conduct the research by definition of the best method for our set of objects and variables.

The purpose of this research is the methodology development of estimation the urban public transport system's quality indicator in case where some values of initial characteristics are missing.

2. Research Methodology

Let's assume that there are values of *M* sub-indicators describing urban system of public transport for *L* cities. A part of cities (*N*) do not have any skips in sub-indicator values, while (*L-N)* cities do have gaps in data.

The investigation will be performed in three stages. The research algorithm is presented on Figure 1.

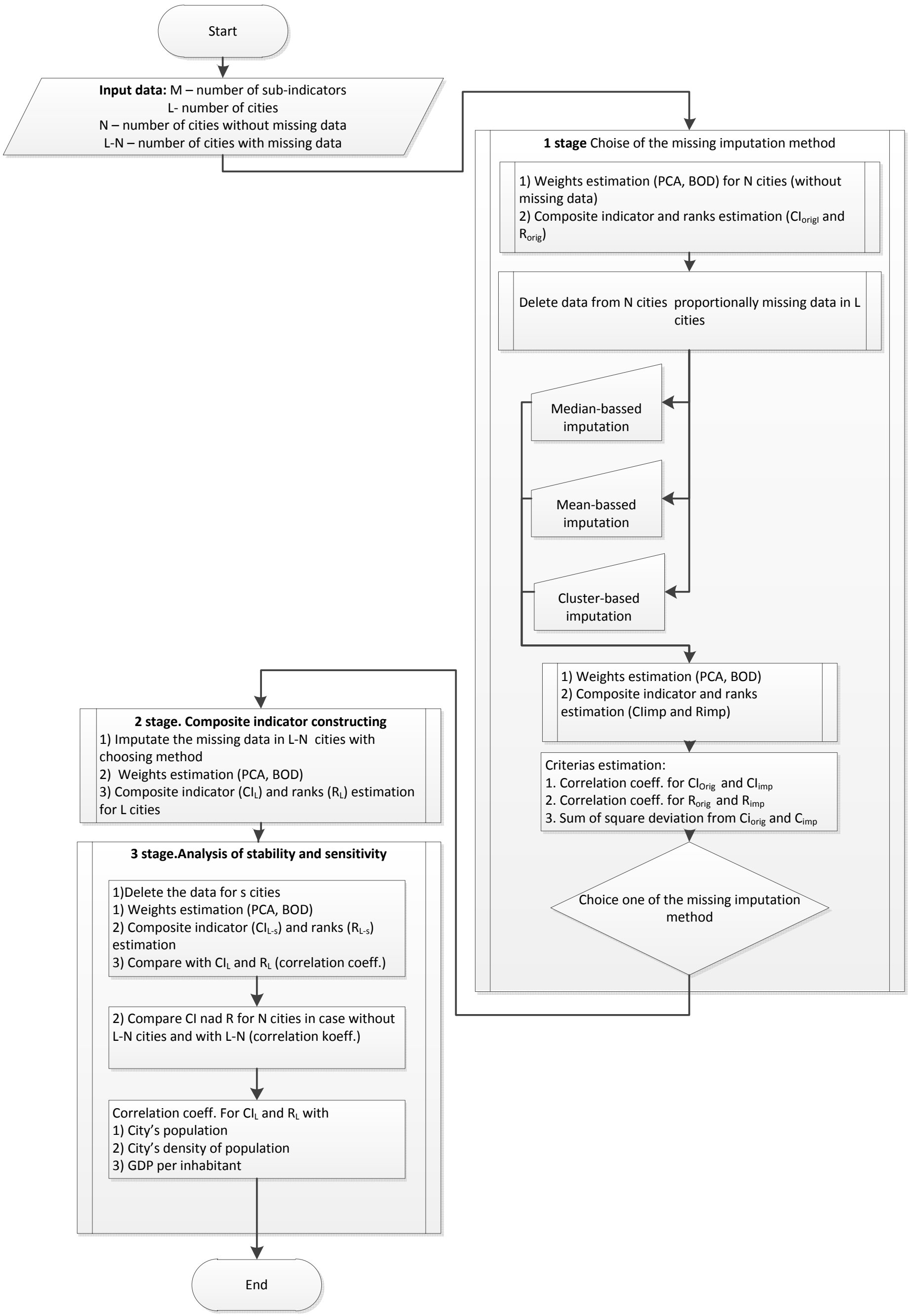

Figure 1. The research algorithm

At the first stage, we shall investigate the influence of missing data imputation methods on the composite indicator value. Let's remove some values from the data set where sub-indicator values are known (N cities) – pro data missing values in the complete data set (L-cities). For imputation of the missing data in considered data set the following methods were used:

- unconditional mean imputation;
- imputation by median;
- clustering-based imputation.

The method of *unconditional mean imputation* is the simplest one. It has been included into the investigation as the method most frequently used in statistical software. It implies estimation of missing values $x_{i,j}$ by the average value $\overline{x_j}$.

$$\overline{x_j} = \frac{1}{n_j}\sum_{i=1}^{n_j} x_{i,j} \ , \tag{2}$$

where $x_{i,j}$ – value of sub-indicator j for object i,
n_j – count of objects with fully observed sub-indicator j.

The *median* of the distribution could be calculated on the available sample and to substitute missing values.

Various approaches for missed data imputation, implying cluster analysis, are known. In this work, we consider the *clustering-base missing data imputation* based on the following steps:

1. One of the methods of cluster analysis is applied to objects without missing data, – and C clusters are singled out.
2. The distance to the centres of all the C clusters is calculated with respect to each i object of observation having some missing data:

$$D_{i,c} = \sqrt{\sum_{j=1}^{m} (x_{i,j} - \overline{x_{j,c}})^2} \ , \tag{3}$$

where $D_{i,c}$ – distance between object i and cluster c,
$x_{i,j}$ – value of sub-indicator j (no missing) of object i,
$\overline{x_{j,c}}$ – mean value of sub-indicator j of c-cluster's objects.

Any variables where values are missing are not involved in the calculation of distance.

3. The nearest cluster is determined, with the minimal distance to it.
4. The skipped value of i object is substituted for the mean value of the corresponding variable pertaining to those observations that are attributed to the nearest cluster.

We shall calculate the value of composite indicator (CI) (Eq. 1) and rankings (R) of N cities with respect to 3 cases of missing values imputation. For constructing the composite indicator it was used the ten-step algorithm, which was developed the Organization of Economic Cooperation and Development (OECD) [1]. For calculating weights and aggregating primary indices into the composite indicator methods based on Equal weighting approach, Principal Components and Factor analysis (PCA/FA) model and benefit of the doubt approach (BOD) were considered [1]. Afterwards, the received CI and R values will be compared to original values CI_{orig} and city rankings R_{orig} that had been calculated for the same cities – however, with no skip in data. Then the most appropriate method of missing data imputation will be selected for the given set of data. We shall use as selection criteria:

- the Person's correlation between values CI_{orig} and CI, given in these stage;
- the Spearman's correlation between values R_{orig} and R, given in these stage;
- the sum of deviation square CI from CI_{orig}.

At the second stage, we shall impute the missed values in the full set of data (L cities) by using the method selected at the first stage. We shall calculate weight coefficients, develop composite indicators for all the cities (CI_L) and determine their rankings (R_L).

At the third stage, we shall perform the analysis for sensitivity and stability of results. To do that, we shall calculate the composite indicator value by deleting some cities from the full list, – and then compare the obtained values with R_L and CI_L. Moreover, we shall compare values CI and R that had no skipped data (N cities) – both when data on other cities is available and missing.

3. Construction of Urban Public Transport Quality Indicator

3.1. The Initial Data

Let us consider as the object – the urban system of public transport, as composite indicator – urban public transport quality indicator – UPTQI and as the sub-indicators – the particular quality characteristics. The database EUROSTAT has been analysed about presence of the UPTS data for the European cities. The data from national sources has not been used, as they are not always calculated with use of one methodology. 21 indicators, which characterise the urban public transport system, have been found in data base EUROSTAT [2]. Unfortunately, the values of mentioned indicators in the database are missing for many cities. Therefore, in the given research the group of the cities (objects) with the most set of the indicators values has been used and special attention in the given work was attend to the quality of the composite indicator construction in case with the missing data. To conduct the investigation, the data describing UPTS in 62 European cities were used with respect to 2003–2006 moments of time. The values of 8 indices shown in Table 1 were used in this investigation.

Table 1. List of sub-indicators

№	Sub-indicators	Code
1	Proportion of journeys to work by public transport (rail, metro, bus, tram)	x1
2	Length of public transport network / land area	x2
3	Number of stops of public transport per km2	x3
4	Cost of a monthly ticket for public transport (for 5–10 km)	x4
5	Number of stops of public transport per 1000 pop.	x5
6	Number of stops per 1 km of public transport network	x6
7	Proportion of public transport network on fixed infrastructure /Proportion of public transport network on flexible routes	x7
8	Proportion of the area used for transport (road, rail, air, ports)	x8

Sub-indicators *x2, x3, x5, x6* and *x8* characterize the availability of UPTS, *x4* – the economic component; *x7* – the environmental impact (since the fixed-route transport uses alternative fuel (as electricity for example). *x1* – may be attributed both to accessibility indicators and subjective indicators – i.e., the attitude towards the quality service as offered by the system: tenants tend to prefer the system more frequently if it provides a higher quality. Unfortunately, no data on other characteristics could be found – like, for example, indices that would characterize the safety of UPTS in these cities.

To construct the indicator with respect to the complete set of data, we shall use the data describing 62 European cities, from them: 37 German cities (without missing data) and 25 other European cities (basically capitals, 3 from them don't have missing data and 22 with missing data in sub-indicators values, but no more than 3 missing values). The largest number of skips in the complete information is observed in values of following sub-indicators: *x1* – Proportion of journeys to work by public transport (rail, metro, bus, tram) and *x8* – Proportion of the area used for transport (road, rail, air, ports)). The total number of missed values is 34 out of 496 which makes 6.85% from the total number of values. Out of that number, 17 values are missing with respect to variable *x1* (27% from 62 values), and 8 values with respect to variable *x8* (13% from 62 values.).

3.2. Analysis of the Influence of Missing Data Imputation Method on Composite Indicators' Scores

In the previous investigation [3] the composite indicator describing the quality of urban public transport was developed for 37 cities of Germany having no gaps in data. We shall call these values original CI_{orig} and R_{orig}.

To investigate the influence of missing data imputation methods on the composite indicator value, let's delete approximately 6.85% of the values from the data describing 37 German cities pro rata the volume of missing values in the complete initial data set; out of them, 10 values with respect to variable *x1*, 5 values with respect to variable *x8*, and 5 random values with respect to other variables. Let us substitute the missing values by using 3 methods of missing data imputation: unconditional mean imputation, imputation by median and clustering-based imputation. Let's calculate the composite indicator for all the three cases. We shall use two methods – PCA and BOD to calculate the weighting factor.

Figures 2 and 3 show normalized values of the composite indicator (CI_{PCA} and $CI_{\boldsymbol{BOD}}$) calculated with respect to cases implying substitution of missed values by using three methods – for 4 cities. The obtained values are presented as compared to original values.

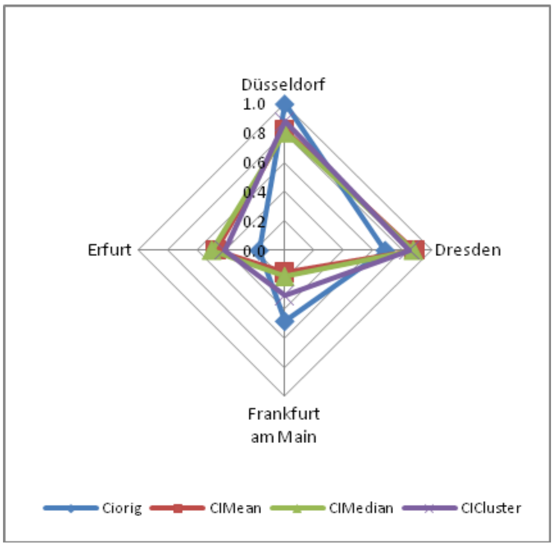

Figure 2. The values of CI_{PCA}norm

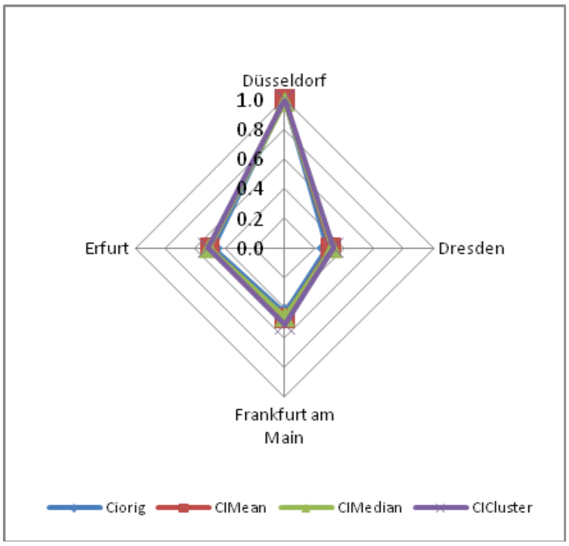

Figure 3. The values of CI_{BOD}norm

Table 2 and Table 3 shows the correlation ratio between the original values CI_{orig} and R_{orig} with the values received in the case implying gaps in data, where the weighting factors are calculated by two methods – BOD and PCA. Table 4 shows the values of the sum of squared deviations from the true value of composite indicator.

Table 2. The value of Pearson's correlation with originals CI norm

Methods	PCA	BOD
Mean	0.867	**0.971**
Median	0.867	0.967
Cluster	0.914	**0.971**

Table 3. The value of Spearman's correlation with originals R

Methods	PCA	BOD
Mean	0.815	0.941
Median	0.806	0.932
Cluster	0.837	**0.950**

Table 4. The sum of squared deviations for *CIorig* and *CI* what calculated with imputation

Methods	Mean	Median	Cluster
PCA	0.0180	0.0175	0.0120
BOD	**0.0047**	0.0054	0.0052

The largest value of correlation coefficient between the calculated CI and CI_{orig} , also, between R and R_{orig} is observed for values obtained by the BOD method (the values are marked in Tables 2 and 3). Besides, applying the method of missing data imputation by mean data yields the composite indicator value closer to the original one; however, one yields the rank city value closer to the original when missing data is replaced by cluster-based missing data imputation approach. Moreover, the BOD method yields the least value of SSD (sum of squared deviations) when substituted by mean values – 0.0047.

So, to calculate the weighting coefficients, we shall use the BOD approach as the least sensitive to gaps in data.

3.4. The Estimation of the Composite Indicator Values for 62 European Cities

Let's calculate the composite indicator for the full data set – 62 cities. Then, we impute the missing values by using the method based on the cluster analysis. As a result of applying the cluster analysis, 4 clusters have been singled out for 37 German cities. Let's determine the cluster to which the distance is the least one, for each of 22 cities having gaps in data. Then we substitute the missing values by the average value of missing variable in the cluster selected. Further, we calculate the weighting coefficient w_i and the composite indicator value CI_{62} by using BOD approach. Table 5 and Figure 3 show the values of CI_{62}, the normalized values of composite indicator ($CI_{62}norm$), ad the rankings (R_{62}) for some cities. The cities have been ranked in descending order of the normalised CI_{62} – from Torino ($CI_{62}norm = 1$) to Schwerin ($CI_{62}norm = 0$).

Table 5. The values of composite indicator and ranks of cities

Ranks	Cities	CI_{62}	CI_{62} norm
1	Torino	1.018	1
2	Madrid	1.013	0.992
3	Helsinki	0.979	0.940
4	Bratislava	0.945	0.889
5	Brussel	0.935	0.874
6	Rotterdam	0.855	0.753
7	Warszawa	0.842	0.733
8	Kosice	0.827	0.711
9	Genève	0.819	0.699
10	Wien	0.819	0.698
…			
18	Berlin	0.692	0.506
…			
22	Dresden	0.664	0.463
23	Düsseldorf	0.654	0.449
…			
26	Riga	0.625	0.406
…			
61	Bielefeld	0.362	0.008
62	Schwerin	0.357	0

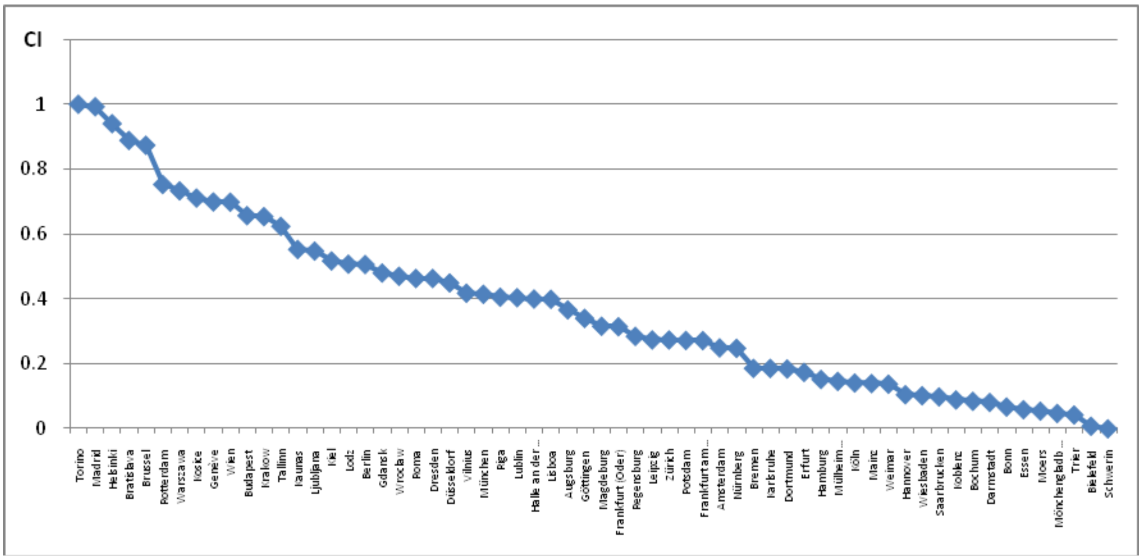

Figure 4. The values of CInorm for 62 European cities

3.5. The Sensitive and Stability Analysis

To perform the sensitivity analysis of the obtained results, the data describing 3 cities was deleted from the cities lit (one by one):

- Torino (ranking first in the ratings of cities);
- Lisbon (the largest number of gaps in data – 3 missing values);
- Ljubljana (the indeterminate value in the variable – Proportion of public transport network on fixed infrastructure/Proportion of public transport network on flexible routes).

For each of 3 cases, composite indicator values were calculated and compared to the value CI_{62}. High values of correlation coefficient (the value of Pearson's correlation > 0.98) attest to the stability of the yielded results.

Also, for stability analysis, let's compare *CI* values to the rankings of 37 German cities yielded at the first and the second stages. Figure 5 shows the rankings of 37 German cities calculated both with and without using any data describing other cities (R_{37} and R_{62}). In both cases, BOD method was used to calculate the weights' values.

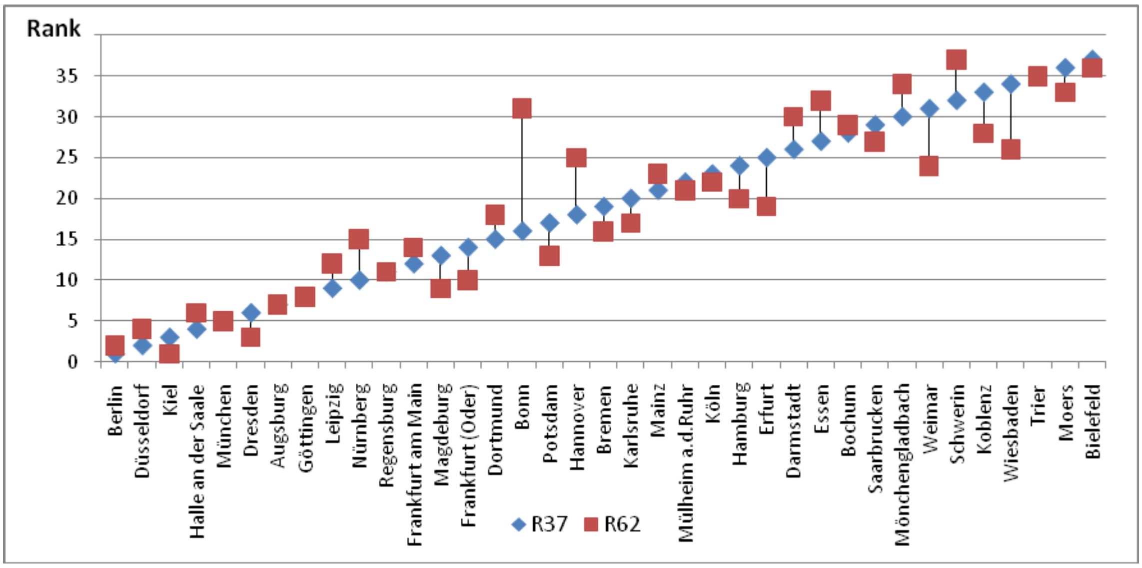

Figure 5. The ranks of 37 German cities

The high value of the correlation ratio between normalised *CI* values (the value of Pearson's correlation 0.94) and the rankings yielded for 37 German cities – both with and without other European cities included (the value of Spearman's correlation – 0.92) attest to the stability of the yielded results.

4. Conclusions and Discussion

In the course of the investigation, a composite indicator for 62 European cities with missing data was developed. The clustering-based method was selected as the most appropriate one for imputation of missing data. For weights calculation the BOD method was used as the least sensitive to gaps with respect to the given set of data.

Moreover, a methodology of composite indicator calculation in case with missing data was developed. The methodology includes the steps as follows:

1. Calculation of composite indicator for cities without missing data in sub-indicator values.
2. Simulation of gaps within the data set with no gaps pro rata the number and the distribution between variables in the full set of data.
3. Substitute of missing values by using a few methods and calculation of composite indicator values for each specific case.
4. Selecting the most appropriate method of missing data imputation by using the follows criteria:

- the Person's and Spearman's correlation coefficients with original *CI*;
- the Spearman's correlation coefficients with original ranks of cities;
- the sum of deviation square from original *CI*.

5. Substitute the missing values in the full data set by using the method selected at the previous stage, and calculate the composite indicator value with respect to the full data set.
6. Perform sensitivity and stability analysis of the yielded results.

The obtained results stated in the article provide a basis for the further investigation of composite indicator construction methods to be used for estimating the Public Transport System.

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OPTIMISATION OF THE SUPPLY CHAIN PROCESS FOR THE LOGISTICS CENTRE

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In this paper the problem of decision-making process for creation of the new supply and distribution channel of the Logistics centre is observed. The task consists in decision-making regarding the way selection from choosing the raw materials till final products creation that allows getting the maximum profit to the company.

This task could be solved by using the method of dynamic programming. In this case it means to make decision for each unit individually.

The solution of the real task for Logistics centre in Latvia is observed in this paper as the numerical sample of decision-making process for the new supply and sales channel development in order to get the maximum profit for the Logistics centre.

Keywords: decision-making, supply chain, dynamic programming

1. Introduction

In order to optimise the supply chain process through the Logistics Centre the management of the textile company makes a decision to create the new supply channel for materials and sales of ready-made goods.

It is necessary to make certain decisions regarding relating parts of supply chain process such as purchase and delivery of raw materials, production and sales of ready products. Therefore the model with different possible scenarios of development has been created.

The first stage is choosing the producer of basic material (clothing). There are offers from three main production companies. The first of them offers the high technological and specialised materials of the best quality according to existing market prices. The second one is ready to supply wide use material of good quality with discount of 10% from market price. The third producer makes middle class materials of lower quality according to confirmed standards and gives discount of 25% from market price. It is necessary to foresee three scenarios of development for each producer that are 1) materials will be produced in time; 2) materials will not be produced by any reason; 3) materials will be produced with delays. Two months are planned to spend for material production.

The second stage is delivery of materials to the final goods production place. Choosing the transport way it is important to pay attention to delivery time, safety and transport rates. Transportation could be provided by shipping line using combined cargos sea container, by air, by road and using the express delivery by courier mail. If materials are produced in time, the low cost transportation ways are preferable, for example, delivery by sea as the cheapest but certain time demanded. Aircraft delivery usually is chosen for quick deliveries. Delivery by road is effective for rather short destinations. In case of time shortage priority of delivery belongs to express service of courier mail as the quickest possible, however the most expensive as a rule.

After delivery cargo could appear in three conditions:

1) materials are delivered till final destination and come to production process;
2) cargo is delivered till transit terminal (cargo warehouse, sea port airport) and further delivery till production place is necessary. In the same time perhaps a part of materials could be stocked temporarily in terminal by any reasons;
3) there is probability of cargo damages and shortage.

The third stage is sales of the ready-made goods. There are three current channels of goods realization:

1) through company’s own shops net;
2) through the wholesalers;
3) through the foreign distributors.

Each products realization scenario has one of the three uncertain results:

1) goods have high demand that create successful sales and high profit;
2) goods take middle market position and taking into account the costs for goods creation they are not profitable but sales cover the losses;
3) in spite of all efforts, products are not interested the customers, sales figures are very low, and company has losses.

As the criteria for effectiveness of making decisions let’s look at as follows:

1) maximum probability of the best effect achievement;
2) average profit maximization.

In the best way, with high demand and successful sales the goods collection should be realized for the minimum time.

Consequently, the task consists in the taking decision regarding the basic materials suppliers, transport way selection and sales channel. In other words it is necessary to choose the way from selecting the raw materials till final products creation that allows getting the maximum profits to the company.

2. Construction of the Mathematic Model of the Decision Choice

Concerned decision-making process could be presented as a net structure *T*, as it shown on the Fig. 1. "Taking decision tree" images the immediate and future decisions regarding materials supply and goods realisation channel. The net includes arcs and vertices of two kinds.

Circle points describe state of the system after decision taking moment. All circle points have the ordinal numbers from 0 to 10. Then state without entering arcs is named source point and corresponds to the initial moment of decision-making process. Further vertices 1, 2, 3 describe the condition related to the suppliers. For instance, state 1 – the most successful status, to be exact materials produced in time.

At least one or more arcs enter all states except of number 0. Arcs correspond to transitions from one state to others. Terminals are the states without running out arcs. They correspond to the final moments of decision-making. In Table 1 is described sense of all 10 states.

Table 1. Status Description

State number	Condition
0	Initial moment of decision-making process
1	Materials are produced in time
2	Materials are not produced by any reason
3	Materials are produced but with delay
4	Materials are delivered to destination point and given to further production
5	Materials are delivered to transit terminal (cargo warehouse, sea port, airport) and demand further delivery till production place
6	Destroying or missing of materials
7	Part of materials is put on stock for future production
8	Goods have high demand that create successful sales and high profit
9	Goods take middle market position and taking into account the costs for goods creation they are not profitable but sales cover the losses
10	In spite of all efforts, products are not interested the customers, sales figures are very low, and company has losses

Diamond vertex corresponds to making decision. Diamonds 0, 1, 2 correspond to producer's choosing. For example, the vertex 0 is the 1st above described producer. The equivalence between vertex number and above mentioned decision is presented in Table 2

Table 2. Vertexes Allocation of Decision-Making Tree

State number ***Development stages***	**0**	**1**	**2**	**3**
1-st stage: choosing of producer	Producer of the high technological and specialised materials of the best quality according to existing market prices	Producer of wide use material of good quality with discount of 10% from market price	Producer of middle class materials of lower quality according to confirmed standards and gives discount of 25% from market price	-
2-nd stage: choosing of transport	Delivery by sea as the cheapest but time-consuming	Air delivery as more expensive but rather quick	Express service of courier mail as the quickest possible, however the most expensive	Delivery by road is effective for rather short destinations
3-rd stage: choosing of realisation way	Through own shops net	Through the wholesalers	Through the foreign distributors	-

Diamond entering arc shows the concrete making decision. Running out arc shows the system possible state after this decision-making.

Making of concrete decision does not mean getting of single result. On the vertex running out arcs probabilities of possible further state are mentioned. In total probabilities sum is equal to 1. For instance, after choosing the producer of basic materials the system could be found in state 1 with probability 0,1 if the first producer is chosen. In case the second producer is chosen it will be there with probability 0,5. The system could be in the same 1 state with probability 0,8 if the third producer is chosen. State 2 is the final as the activities come to unsuccessful result and have no further development. So there are two states with future development left.

The next row of diamonds (2nd stage) is choosing of the transport company and delivery way from basic material production till the place of further processing. There diamonds num`bers show the choice of the early mentioned transporters.

The last third row of diamonds (3rd stage) present the choice of ready-made goods realisation way.

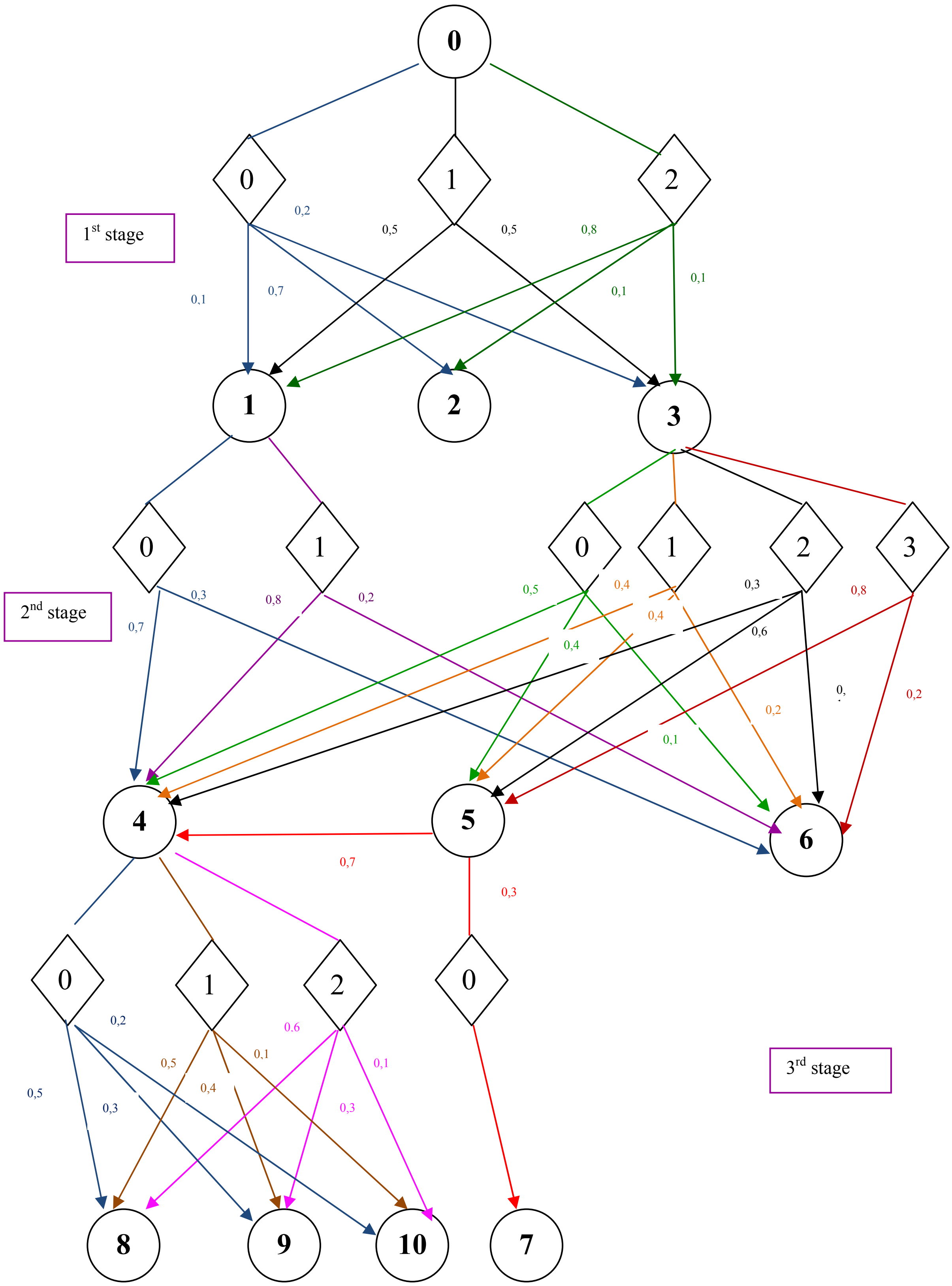

Figure 1. Net structure "Decision-making tree"

Let us describe the mathematical view (conception) of initial data.

States are known for each position following for the previous ones. For example, they are presented by matrix T, shown in the Table 3. Rows of the matrix correspond to current states, columns corresponds to different decisions. Matrix elements show numbers of the future states. Here the symbol – 1 means the absence of future state.

Table 3. Matrix *T*

$T^T =$

	0	1	2	3	4	5	6	7	8	9	10
0	1	4	-1	4	8	4	-1	-1	-1	-1	-1
1	2	6	-1	5	9	7	-1	-1	-1	-1	-1
2	3	-1	-1	6	10	-1	-1	-1	-1	-1	-1

One single decision should be made from several ones in each state except of terminal. The probability of transition to the next state is changing depending on taken decision. Let $Prj_{i,k}$ be a probability of a transition from state *i* to state *k* if decision *j* has been chosen. A corresponding matrix is named as *Prj*. For instance matrix *Pr0* in bellow table 4. Rows of the matrix *Prj* correspond to different vertexes, columns corresponds to different states. Matrix *Prj* elements show corresponding probabilities. For that numbers of states are determined by matrix *T*.

Table 4. Matrix *Pr0*

$$\mathrm{Pr0} := \begin{pmatrix} 0.1 & 0.7 & 0.2 \\ 0.5 & 0 & 0.5 \\ 0.8 & 0.1 & 0.1 \end{pmatrix}$$

We have expected revenue amount for achieving of all states. They are presented by vector *c*. Table 5 contents corresponding example.

Table 5. Expected revenues for each state *c*.

State, j	Profit, cj	Probability Coefficients, ĉj
0	0	0
1	-10000	0
2	-500	0
3	-12000	0
4	-5000	0
5	-500	0
6	-5000	0
7	-2000	0
8	30000	0
9	40000	0
10	60000	1

There are several criteria for effectiveness of making decisions could be offered:

1) maximum probability of the best effect achievement;
2) average profit maximization.

Reward of different states sum up together. Total value is a random variable as result of random transition. The task is to choose the decision for each state in such way that the average amount becomes maximal of total profits.

Method of Dynamic Programming will be used for this aim.

3. Method of Dynamic Programming

Dynamic programming supposes the decision-making step by step. In our case it means decision-making for each state individually. Look at the moment of time when it is need to make a decision for state *j*. Here it is important to mention that if state *j* is not terminal, till that moment should be checked states with bigger then *j* numbers.

Let's enter Bellman function $F(j)$, this is the maximum average profit, which could be getting starting from state j till the end moment of decision-making process. To calculate these functions we have the following Bellman equations:

$$F(j) = \underbrace{\max}_{k \in D(j)} \left\{ c_j + \sum_{i \in \mathrm{Sjk}} \Pr j_{i,k} F(i) \right\}, \tag{1}$$

where
S_{jk} – set of state numbers, following the state j if decision k is taken
$D(j)$ – a set of possible decisions in state j.

These equations should be used starting from the terminal states and going to the root (initial state). Terminal states are final, so the first item leaves in brackets in the formula (1). In the same time decision k^* is fixed for each state as the optimal one. For this decision the value in brackets coincides with $F(j)$ in formula (1). So this procedure is named as *the inverse running* of dynamic programming.

Direct running gives the quantities (order) of optimal decisions for all states. It is realised in opposite direction of the above mentioned inverse running – from the root to the end units, each time moving from state j to one of the following states that corresponds to optimal decision k^* in the state j. Direct algorithm is finished when all the states are calculated till that ones who have no future states.

4. Computer Realization

The described algorithm is realized by program *OptValue*. This programme gives the matrix that has two columns: the first one corresponds to maximum profits $F(j)$, the second one corresponds to optimal decisions k^* for each position j. This program was created by using the mathematical package MathCAD 14

Primary data for program is the following:

- Matrix T, describing the examined net. Rows of the matrix correspond to net states, rows elements show numbers of the further states. Value –1 means the absence of the next states.
- Vector c describes profit that comes for achieving each state.
- Matrix Prj of transit probabilities for state j. Rows of the matrix correspond to different decisions k, but columns correspond to the next state (with respect to the matrix T), main program *OptValue* uses the auxiliary program $Pr(j)$ that gives the matrix Prj according to number j.

5. Numerical Results

For our example we have the following numeric data mentioned in Tables 3, 5, 6.

Table 6. Matrixes of the probabilities

$$\mathrm{Pr0} := \begin{pmatrix} 0.1 & 0.7 & 0.2 \\ 0.5 & 0 & 0.5 \\ 0.8 & 0.1 & 0.1 \end{pmatrix} \qquad \mathrm{Pr1} := \begin{pmatrix} 0.7 & 0.3 \\ 0.8 & 0.2 \end{pmatrix} \qquad \mathrm{Pr2} := (1)$$

$$\mathrm{Pr3} := \begin{pmatrix} 0.5 & 0.4 & 0.1 \\ 0.4 & 0.4 & 0.2 \\ 0.3 & 0.6 & 0.1 \\ 0.8 & 0.2 & 0 \end{pmatrix} \qquad \mathrm{Pr4} := \begin{pmatrix} 0.5 & 0.3 & 0.2 \\ 0.5 & 0.4 & 0.1 \\ 0.6 & 0.3 & 0.1 \end{pmatrix} \qquad \mathrm{Pr5} := \begin{pmatrix} 0.7 & 0.3 \end{pmatrix}$$

As the criteria we choose optimisation of achieving the state 10, as the profit vector $\hat{c} = (0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1)^T$.

The next step is using the program *OptValue*, to make the calculation for optimal decisions and maximum average profit, done by known rules for Markov chains. Table 7 presents the results of calculations.

Table 7. Maximum Probability of The Best Effect Achievement

State number	0	1	2	3	4	5	6	7	8	9	10
Profit	0.16	0.16	0	0.16	0.2	0	0	0	0	0	1
Making decision	1	1	0	3	0	0	0	0	0	0	0

Using the data from Table 5 we calculate the average profit maximization in terms of money. Here the profit vector is c = $(0\ -10000\ \ -500\ \ -12000\ \ -5000\ \ -500\ \ -5000\ \ -2000\ \ 30000\ \ 40000\ \ 60000)^T$

Table 8. Maximum Average Profit for Vector c

State number	0	1	2	3	4	5	6	7	8	9	10
Profit in money term	15600	16200	-500	15000	34000	-2500	-5000	-2000	30000	40000	60000
Making decision	1	1	0	3	2	0	0	0	0	0	0

Conclusions

The task of the decision-making process for Logistics centre Supply Chain optimisation through the creation of the new supply and sales channel in optimal way was observed. There are some various decisions could be taken at each stage of process development. The ways differ from each other by necessary resource and profit receiving. Two aspects, such as maximum probability of the best effect achievement and average profit maximization are taking as the criterions for effectiveness of making decisions.

The task is solving by using the method of *dynamic programming*, created by Richard Bellman. During the work using the MathCAD 14 package the special program which helps to make the calculations is created.

Using the dynamic programming method the real formulated task of decision-making process for the new supply and sales channel development for the Logistics centre in Latvia is solved and the solution for getting of optimal profit is found.

Acknowledgement

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DEVELOPMENT OF SEGMENTATION METHOD BASED ON "MASS CENTRE" APPROACH FOR VIDEO SURVEILLANCE DATA OF TRANSPORT VEHICLES FLOW

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The increasing traffic in the European Union puts in the forefront the need to create intelligent transport systems of traffic control (ITS) at district, urban and regional scale. Structurally, such systems include a network of sensors of primary or indirect measurements of traffic flows, a control centre and a network of executive components (traffic lights, controlled traffic signs, reversible lanes, etc.). The wider the network of sensors, the more complete information is available for high quality of the intelligent control. Currently, video, laser, radio frequency, induction, and pressure sensors are mainly used as sensors of traffic flows' parameters. The deployment of a network of such sensors requires significant financial resources, and sometimes also additional construction work. Installation, maintenance and protection of an expensive network of sensors and their channels of communication make the creation of full-scale ITS rather expensive, which is not affordable at all.

The possibility of using mobile video detection system to measure traffic is discussed. This mobile system consists of a notebook and simple web-camera, which is the cheapest version of the video sensor. Video data processing is done by stages: detection, segmentation, classification and tracking. Algorithm for finding and identifying vehicles on each frame of video stream is proposed. Algorithm is based on finding "mass centre" of all "good features" on each video frame. This allows identifying vehicles and helps to escape noise and unwanted motions on the frame. Tracking of "mass centre" and other properties allows identifying transport vehicles during motion through the view port. Different cases of transport vehicle mutual intersection are processed.

Keywords: segmentation, computer vision, detection, tracking, transport vehicles

1. Introduction

Currently, the transport stream automatic analysis is one of the priority tasks in traffic optimisation. Information about traffic streams load, transport vehicle quantity and transport types allow optimising traffic lights more efficiently, thus decreasing the time of transport vehicles standing on the crossroads and avoiding traffic jams. Also, the analysis of this data may help in choosing the project for further transport system development [1].

Today, to determine a certain transport stream usage load, a lot of different systems are being used, which can be differed by an operating principle and measured parameters. The following systems have been examined: inductive [2], pneumatic [2], magneto-metric, piezoelectric, infrared, ultrasound systems, as well as video detection and surveillance systems. The mentioned systems have common drawbacks. They are all very expensive by their cost and installation.

The existing video surveillance and tracking systems are to be installed above the road; this requirement has its drawbacks, especially in the cities. It is also necessary to consider, that many of these systems are intended for one roadway, so, to collect data about traffic stream load properly, the system should be installed on each roadway.

To solve these problems it is necessary to develop a mobile system, which is not expensive, based on a simple computer and web camera. The system should be able to analyse frames from the camera and collect data about transport vehicle quantity on the road. This kind of system can be installed in a car, which is parked on side of the road or parking place, thus solving a problem with system's installation. Data collection will be made from all roadways simultaneously.

For the system these conditions set certain tasks: tracking and registration of all transport vehicles even if mutual overlapping occurred. To solve these tasks it is necessary to examine the methods of video analysing and transport vehicle images segmentation.

Transport vehicle automatic monitoring algorithm

Several phases of transport vehicle automatic monitoring are examined for the purpose to solve our problem [3]. The generalized monitoring algorithm can be seen on Figure 1.

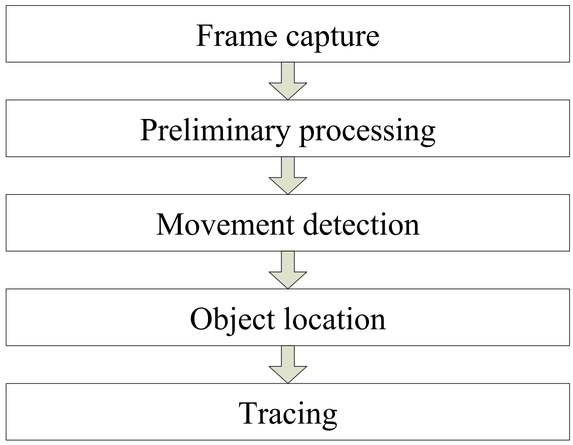

Figure 1. Algorithm scheme

Frame capture

In this phase we need to capture a frame. It can be obtained from camera or video file, which is chosen by user. OpenCV library (Open Source Computer Vision Library) was chosen for convenient frame capture from both. Given library contains different modules for computer vision, video recording and capturing and image processing.

For initial processing it is required to create a module for webcam management. This module will be used to capture frames directly from the webcam. For algorithm start it is required to have two sequential frames.

Preliminary processing

Preparation for captured frame analysis is held in this phase. For image contrast amplification multiplication method is used. It helps to increase the brightness value of each point on all image channels.

Algorithm for preliminary processing is presented by Formula 1.

$$C(x, y) = scale \bullet A(x, y), \tag{1}$$

where: $C(x, y)$ – resulting pixel brightness value in point (x, y);
$A(x, y)$ – pixel brightness value in point (x, y) on the source image;
$scale$ – brightness intensification multiplier.

To avoid processing of the superfluous information (sidewalks, tops of trees, etc.) there is a possibility to change ROI (Rectangle of interest). ROI is a part of the image that needs to be processed.

Movement detection

For movement detection two sequential frames are needed. The difference between them will show only the changed part of the image. To achieve this subtraction method is used.

2. Frame Subtraction Algorithm

Algorithm is shown by Formula 2.

$$dst(x, y) = abs(A(x, y) - B(x, y)), \tag{2}$$

where: $A(x, y)$ – pixel brightness value in point (x, y) of the first frame;
$B(x, y)$ – pixel brightness value in point (x, y) of the second frame;
$dst(x, y)$ – the resulting pixel brightness value in point (x, y).

Example of algorithm usage is shown on Figure 2.

Figure 2. Frame subtraction

As a result we get an image that contains only pixels, which changed their brightness values on two sequential frames. However, this image contains a lot of noise from trees, shadows, etc. In order to proceed to the next phase this image should be cleaned from the noise. To do this we use binary threshold and closure algorithms.

3. Closure Algorithm

This algorithm consists of several methods for image conversion. Basic operations are as follows: erosion and dilation. Erosion of a binary image will set all pixels brightness values to zero, if at least one of the vicinity pixels equals zero. The example can be seen on Figure 3.

Dilation of a binary image will set all pixels brightness values to one, if at least one of the vicinity pixels equals one. The example can be seen on Figure 4.

These rules are applied to all pixels of the image. If an image is multi-channel, then these operations are done on all channels of the image.

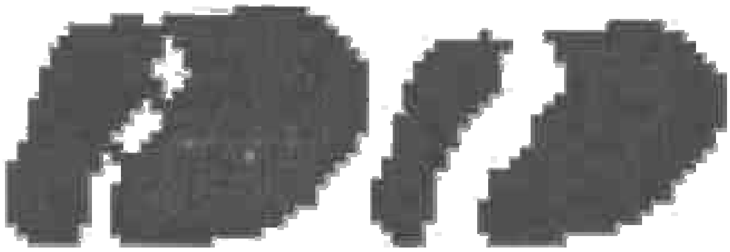

Figure 3. Object erosion [4]

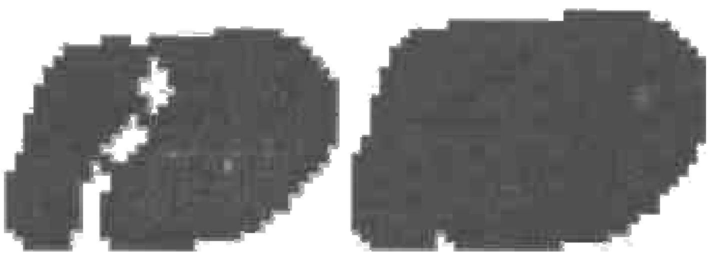

Figure 4. Object dilation [4]

Closure algorithm consists of sequential application of dilation and erosion methods. This leads to deletion of small fragments of background, for example, „holes" (closed areas of background inside object). The algorithm is presented by Equation 3.

$dst = erode(dilate(src))$, (3)

where: *dst* – resulting image;
src – source image;
dilate – object dilation function;
erode – object erosion function.

Algorithm application result is shown on Figure 5.

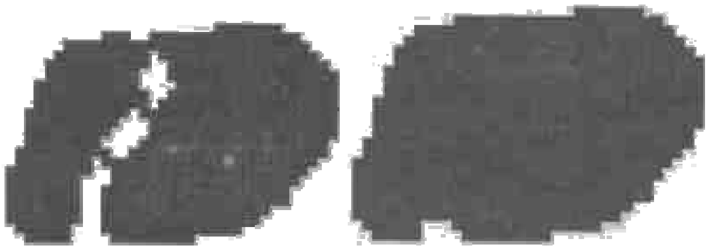

Figure 5. Closure application [4]

4. Binary Threshold Algorithm

Method of setting a threshold for image brightness is a convenient way to get rid of the noise on single-channel and multi-channel images. There are several ways to set this threshold: simple and adaptive. Simple method was chosen, because its effectiveness is sufficient. This method is described by Equation 4.

$$dst(x,y) = \begin{cases} src(x,y) & if\ src(x,y) > T \\ 0 & otherwise \end{cases}, \tag{4}$$

where: $dst(x, y)$ – resulting pixel brightness value in point (x, y);
$src(x, y)$ – pixel brightness value in point (x, y) on the source image;
T – set threshold value.

The pixel brightness value is not changed, if it exceeds preselected threshold. In other cases value is set to zero. Example of initial brightness value and threshold usage result is shown on Figure 6.

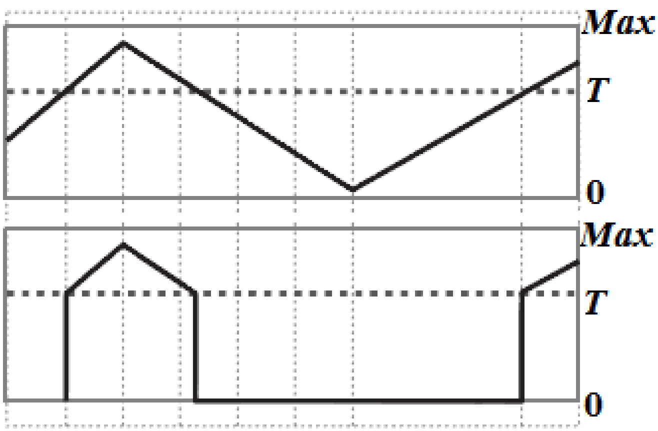

Figure 6. Threshold application

Object recognition

In this phase frame should be analysed for object presence so we can track it subsequently. More often for these purposes Harris [5] detector is used. For every pixel on the image a corner response function is calculated. It estimates similarity degree of the vicinity around a point and a corner. Tensor matrix is calculated in the beginning (see Equation 5).

$$M = \begin{bmatrix} \left(\frac{\partial^2 I}{\partial x^2}\right) & \left(\frac{\partial^2 I}{\partial x \cdot dy}\right) \\ \left(\frac{\partial^2 I}{\partial y \cdot dx}\right) & \left(\frac{\partial^2 I}{dx^2}\right) \end{bmatrix}, \tag{5}$$

where: $I(x,y)$ – image brightness value in point (x, y).

If both values of the matrix are high, the even small displacement of a point (x, y) causes considerable change in brightness, as corresponds to a feature of the image. Corner response function is written in the following kind:

$$R = \det(M) - k(trace(M))^2, \tag{6}$$

where: $det(M)$ – M matrix determinant from equation 5;
$trace(M)$ – the sum of matrix M main diagonal;
k – predefined constant.

Parameter k usually equals 0.04 (suggested by Harris). Points on the image, corresponding to the local maximums of this function are acknowledged as "good features" to track. To achieve subpixel precision quadratic interpolation can be used. To decrease noise influence on found features Gauss smoothing [6] is used for partial derivatives in (5).

$$\left(\frac{\partial^2 I}{\partial x^2}\right), \left(\frac{\partial^2 I}{\partial y^2}\right), \left(\frac{\partial^2 I}{dx \cdot dy}\right), \left(\frac{\partial^2 I}{\partial y \cdot dx}\right), \tag{7}$$

often too many features are found. In future, they will be hard to track. This is why a limit is defined for minimal distance between found features. All unnecessary features are discarded.

Example of this algorithm application can be seen on Figure 7, where found features are shown as white round markers.

Figure 7. Features

Object tracing

The purpose of this phase is to trace objects on sequential frames. The main problem here is to determine which features that were found in the previous phase belong to the object on sequential frames. It is important to have one object considered only once while it moves through the viewport. To solve this problem it is necessary to assign found features to an object on each frame. Then, found objects should be compared to the ones that were found earlier. The matching objects are treated as one object. Algorithm for finding "mass centre" has been offered.

5. Algorithm for "Mass Centre" Finding

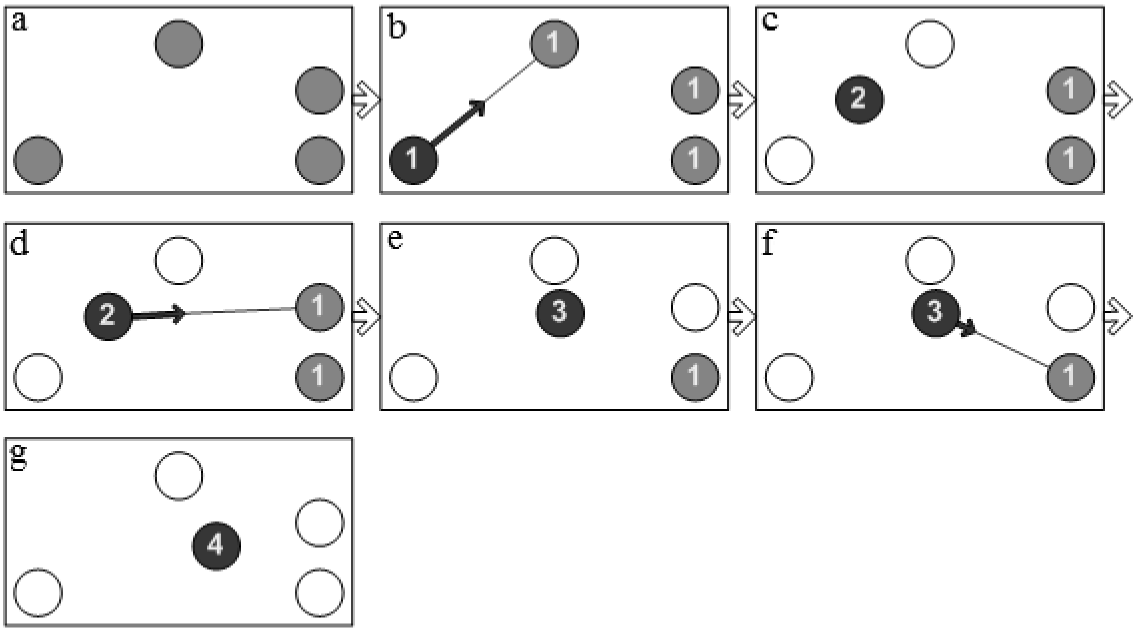

Figure 8. "Mass centre" calculation

Algorithm for "mass centre" calculation consists in finding a point on the image, which is the absolute centre of all features found on previous phase (Figure 8 a). At first, all features are assigned with "weight" value, which equals to 1. Randomly one feature is chosen to be current "mass centre" (Figure 8 b). Then all features are iterated through, and on an iteration "mass centre" coordinates and weight are recalculated. Distance (offset), on which it is necessary to move current "mass centre" is calculated by Equation 8

$$offset = \frac{\min(mass_A, mass_B)}{mass_A + mass_B}, \tag{8}$$

where: $mass_A$ – mass value of the current mass centre;
$mass_B$ – feature mass value;
min – function for finding minimal value;
offset – relationship, that shows the distance on which current mass centre should be moved towards the feature.

Mass centre modification is shown in Equation 9.

$$\begin{aligned} X_{center} &= X_{center} \pm \left| X_{center} - X_{feature} \right| \cdot offset \\ Y_{center} &= Y_{center} \pm \left| Y_{center} - Y_{feature} \right| \cdot offset, \end{aligned} \tag{9}$$

where: X_{center} – current mass centre X coordinate;
Y_{center} – current mass centre Y coordinate;
offset – offset value, derived from Equation 8.

As a result of iterating through all special features we acquire coordinates and „weight" value of the „mass centre". Example of finding these values is shown on Figure 9.

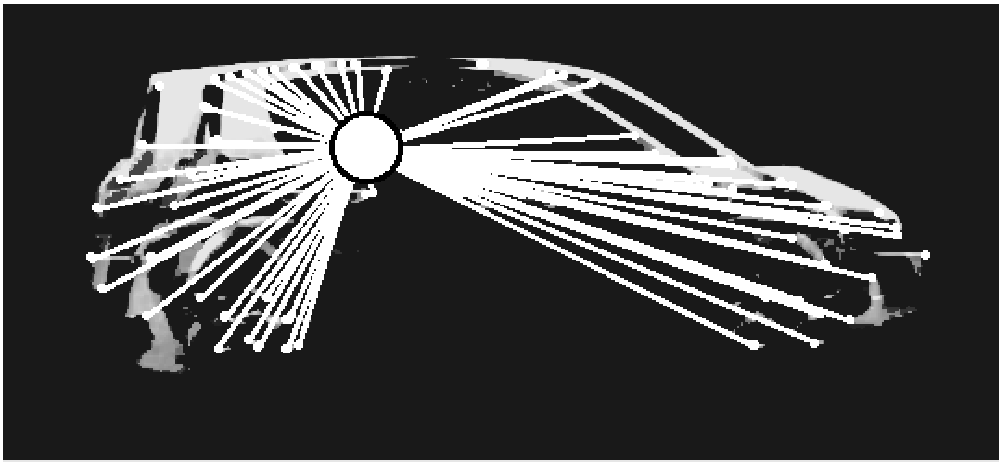

Figure 9. Mass centre

If „mass centre" value does not exceed certain threshold value, then it will not be processed further and counted as an object for processing. Otherwise, object is found and added to memory list. Object properties are the following: value of „mass centre" and its coordinates. In future, found objects will be compared to the ones in the list, and if match is found, then this object is counted as old and not added to the list twice. The properties are updated with new values.

6. Perimeter and Presumed Dimensions

The above mentioned monitoring algorithm can be counted as efficient only in the case, when there is only one vehicle on the frame. If there is a couple of them, then algorithm results will be incorrect, because „mass centre" will be calculated based on special features of all vehicles. Example of this situation is shown on Figure 10.

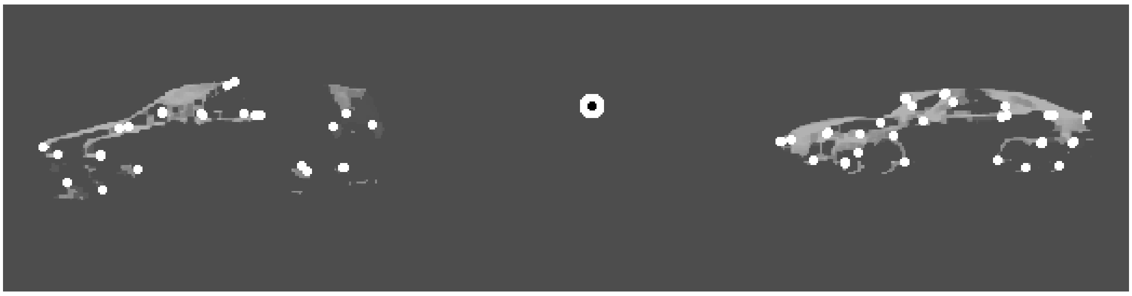

Figure 10. Several objects on the frame

This problem can be solved by adding additional criteria to classify an object. One of them can be a perimeter of all features, found on the frame. The other can be presumed dimensions of the transport vehicle.

To apply these properties to our algorithm we need to calculate a perimeter around all special features on the frame and then add a rectangle of presumed dimensions of a transport vehicle around the „mass centre". On Figure 11 perimeter is a wide rectangle and presumed dimensions rectangle is narrow.

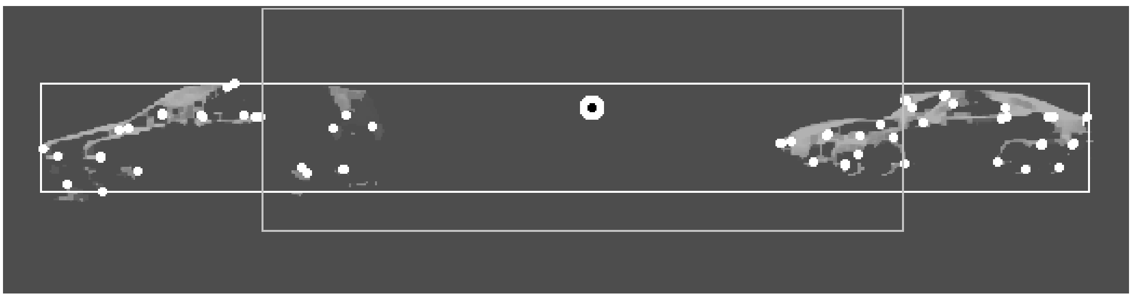

Figure 11. Perimeter and presumed dimensions

Algorithm for finding mass centre needs to be run for the second time now, but only for a zone of intersection between two rectangles. As a result we find less features and „mass centre" will be smaller. Example of this can be seen on Figure 12.

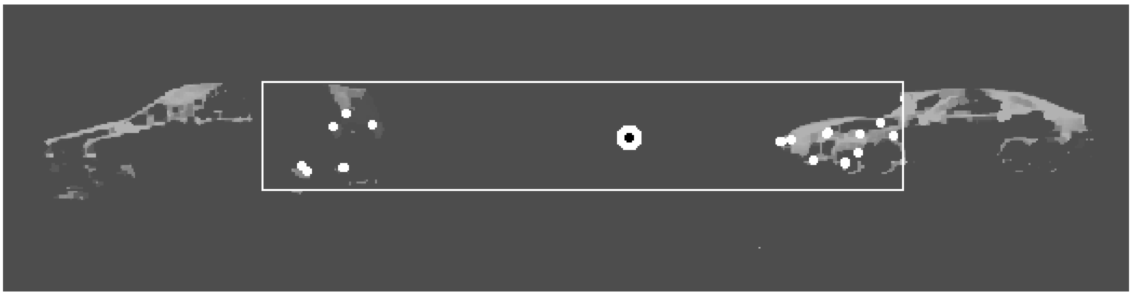

Figure 12. Mass centre new position

Now „mass centre" value won't exceed minimal value for a vehicle, and this object will be discarded. If vehicle enter viewport one after another, then these vehicles will be counted as two.

7. Automobile Opposite Overlapping Separation

Above mentioned algorithm is insufficient for some cases. Different types of mutual overlapping can occur on the road. Example of opposite mutual overlapping can be seen on Figure 13.

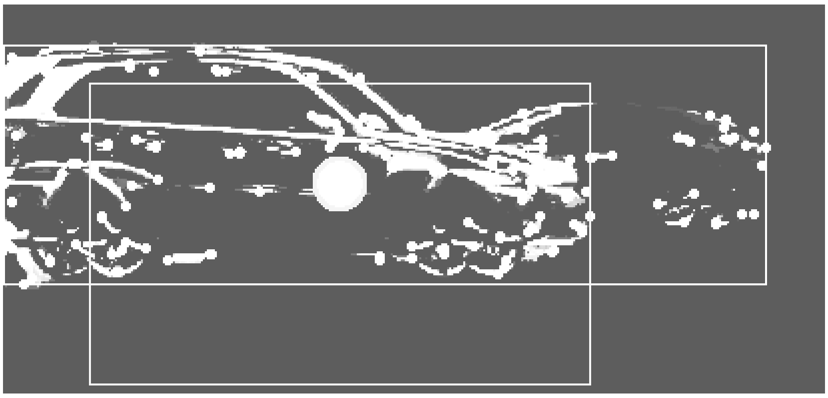

Figure 13. Opposite mutual overlapping

Automobiles will be counted twice in this situation. At first, when they appear on the frame, and second time when they are separated after opposite mutual overlapping. The problem here is that algorithm is not identifying automobiles as unique objects on the frame. Algorithm is not "remembering" information about these objects, which could have helped to identify them.

Every identified object on the frame possesses its own characteristics that differs it from other objects. The aggregate of all these characteristics and the object itself we will call a "blob". So, for the purpose of solving the above-mentioned problem a few tasks has to be implemented:

- Separation of automobiles on frame. Endowing them with unique characteristics to make "blob".
- Create history for "blob" movement through the viewport.

Automobile separation on "blobs"

A modification is needed of the described in the previous chapter algorithm to correctly separate couple of automobiles on the frame.

When there are a lot of "good features" on the frame and a wide perimeter of all "good features" a frame needs to be divided in two. It is separated by found earlier "mass centre". Then, a search for "blobs" should be started again for each part of the frame. An example of frame division and repeated search for "mass centres" can be seen on Figure 14. New "mass centres" are marked with capital letter L and R. Place where frame was divided is shown by thick white line.

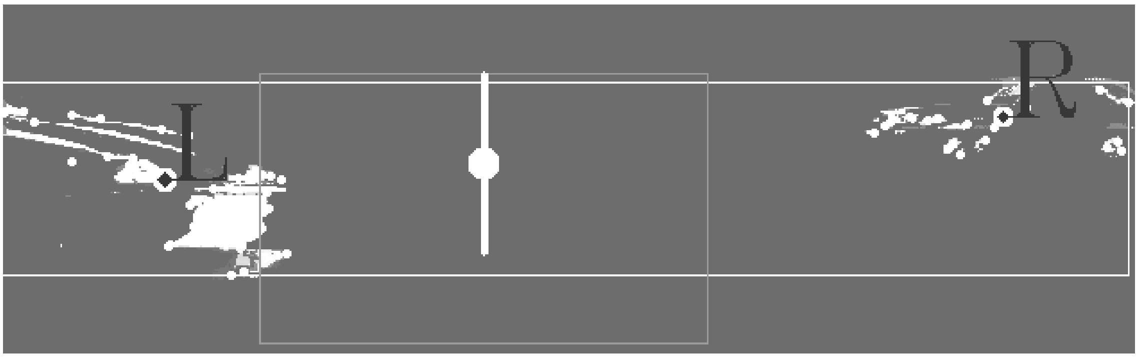

Figure 14. Frame division and additional "mass centres"

Now, these automobiles are identified as different "blobs". Afterwards, to separate them after mutual overlapping we need to assign them some unique characteristics. The following characteristics can be taken to achieve our goal:

- Movement direction.
  This characteristic will facilitate search for "blob" on frame and foresee its next appearance. Determination of "blob" movement direction is done by two first frames, when "blob" entered the viewport. On first frame "blob" is registered as new object for tracking. On second frame this "blob" is found again and identified in history.

- Movement speed
  "Blob" speed is a useful characteristic for foreseeing next appearance of this "blob" on the frame.
- "Good features" perimeter
  This characteristic can be used, because size of moving automobile is not changing during movement. A slight deformation can occur if road is not straight. Perimeter allows tracking "blob" trajectory and determining on which traffic lane the automobile is moving.

- "Mass centre"
  It is most important of the basic "blob" characteristics; allows differ this "blob" from others and tracking "blob" trajectory. This characteristic can slowly change from to frame, due to change of transport vehicle lighting. Additionally, this it can be a good separator for automobiles of different size and colour, because they will have different quantity of "good features", from which "mass centre" is calculated.

These characteristics allows us to unambiguously track an automobile on frame and differ it from others even if it is hidden by other transport for some time.

Creation of "blob" history

Appearance of "blobs" on frame should be registered and remembered. All movements of "blobs" must be recorded in the history for subsequent comparisons. This method allows us to calculate approximate place of particular "blob" on the next frame.

Thereby, all "blobs" acquire history that allows tracking it on subsequent frames. "Blob" identification in history is based on above mentioned characteristics. If "blob" is identified then all information about it is updated with new characteristics. If identification failed, then this "blob" is considered a new object on frame and is registered in the history.

Example of above described algorithm in action

This example will describe how implemented algorithm will act and solve the task of separating opposite mutual overlapping.

Initial appearance of the automobiles on the frame is shown on Figure 15. Algorithm already identified left automobile as a new "blob" and counted it. Information about it is put in history. Right automobile is not yet identified, due to small count of "good features".

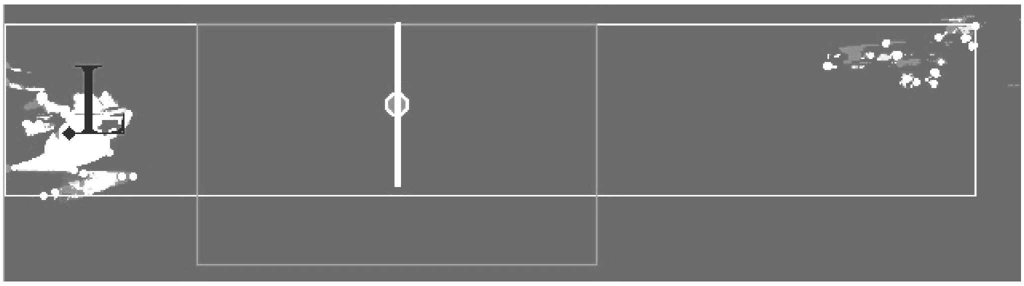

Figure 15. Initial frame

On Figure 16 right automobile is identified as a new “blob” and put in history. Left automobile continues motion and its characteristics are updated on every frame. On this frame left automobile is identified as moving right.

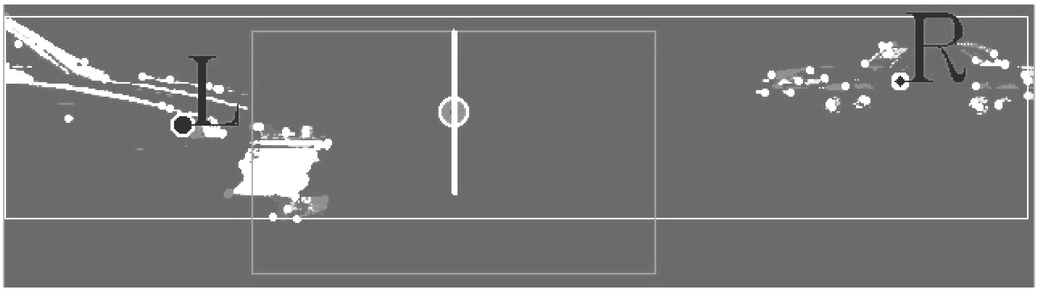

Figure 16. Both automobiles are identified

Overlapping is starting on Figure 17. Right automobile is still identified as a different object.

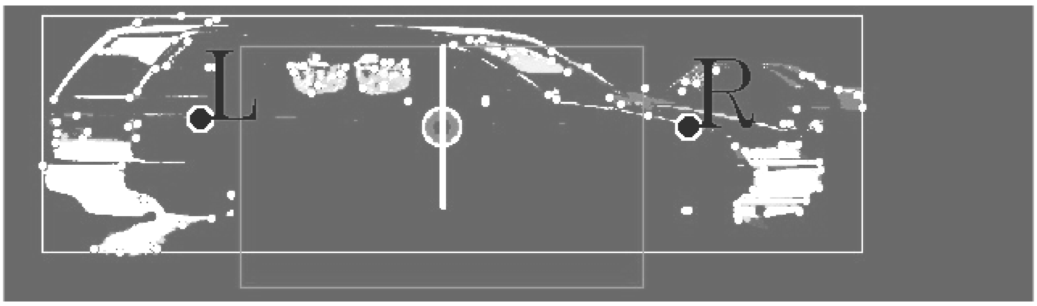

Figure 17. Overlapping start

On Figure 18 full overlapping is shown. Small “right” automobile is completely hidden by other automobile. This big “blob” is identified as one known automobile. History is updated.

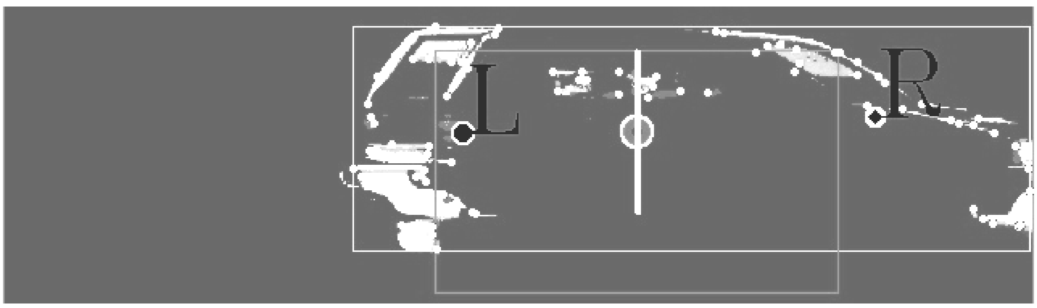

Figure 18. Full overlapping

On the next frame overlapping is ending. It can be seen that algorithm sees only one object now. It is identified as a “right” automobile. History is updated.

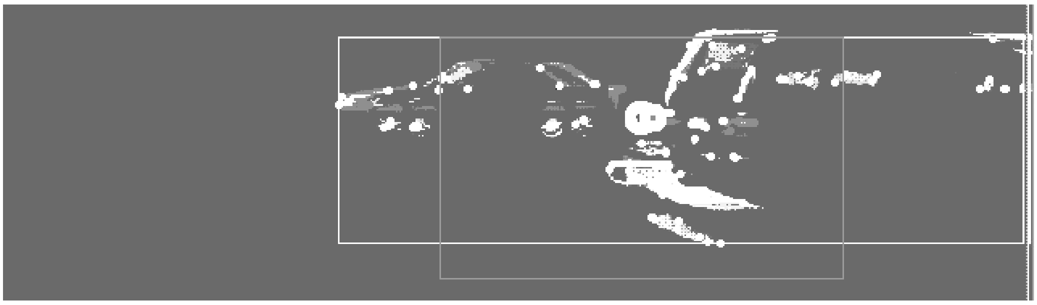

Figure 19. Separation

The automobiles are fully separated on Figure 20. "Left" automobile is now identified as a separate "blob". Algorithm searches the registry for this "blob" and finds a "blob" with similar characteristics. Characteristics in the history are updated with new values.

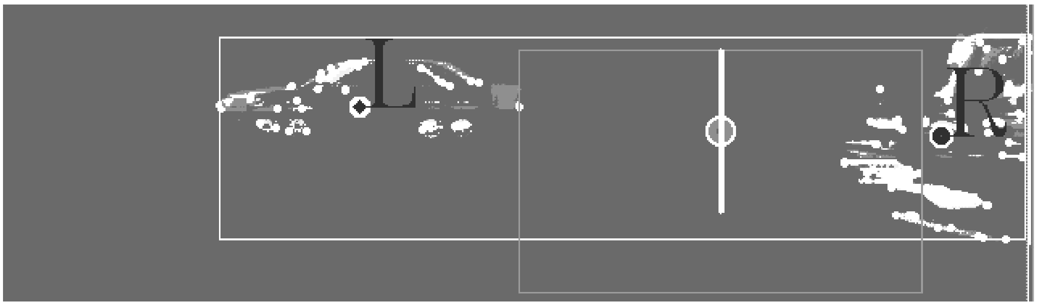

Figure 20. "Blobs" second appearance

As a result, this implemented algorithm allows calculating automobiles correctly, even if partial or full mutual overlapping occurred during movement.

Conclusions & Discussion

The first results show that method, based on calculation and tracking of "mass centre", allows steadily tracking the moving object of fixed size, identifying it in the group and measuring its movement speed.

At the same time, while analysing transport streams, cases of transport vehicles mutual overlapping can be observed. Different variants of overlapping can occur: opposite and following. Opposite mutual overlapping is processed accordingly with the help of "blob" history and characteristics of the "blob".

Presences of different types of foreign objects can complex monitoring of transport vehicles. They include: pedestrians, bicyclists, animals, tree moving, etc.

To acquire accurate data for roadway load status it is necessary to configure the system in the way, to avoid spurious actions of the counter on motioned hindrances. One more factor, which influences the received results, is the level and light exposure uniformity of the roadway, and weather. The quantity of the roadways is one more important characteristic. With a large number of roadways some predefined constants, like presumed dimensions of the vehicle, needs to be adapted.

Problems with high roadway load occur in cases of transport full following mutual overlapping. In these cases correct registration of transport vehicles is possible only if these vehicles are divided at some point in time.

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METHODOLOGICAL FEATURES REGARDING THE PROGNOSTICATION OF LITHUANIAN RAILWAY FREIGHT TRANSPORT VOLUMES FROM A LONG-TERM PERSPECTIVE

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The prognostication of Lithuanian Railway freight transport volumes from a long-term perspective is difficult methodological process even during a period of positive economic development. All sectors of National Economy have serious consequences of international crises and still are not recovered (did not climb out of economic recession). Therefore it is not a time to predict further optimistic development. Social sector having influence on a usage and a growth of its demand is still in more complicated situation. Despite of this unpleasant economic situation the processes of projection, strategic planning, and preparation of priority projects, investment planning and implementation continue to proceed.

That determines urgent modelling of separate economic sectors, forecasting of specific activities and preparation of tactical plans. This attitude was a basis for the methodology regarding prognostication of railway freight and passenger transport volumes from a long-term perspective. Necessity of preparation of priority infrastructure projects and substantiation of their decision determines the period of perspective.

Keywords: railway freights volume, transport flows, DGP projections, providences of the economic development, influence of internal and external factors, forecast of macroeconomic indicators

1. Introduction

Methodologically it is difficult to forecast railway transport volumes from a long-term perspective even during a period of positive economic development. All sectors of National Economy have serious consequences of international crises and still are not recovered and have not yet climbed out of economic recession. Therefore it is not a time to predict further optimistic development. Social sector having influence on a usage and a growth of its demand is still in more complicated situation. Despite of this unpleasant economic situation the processes of projection, strategic planning, and preparation of priority projects, investment planning and implementation continue to proceed.

That determines urgent modelling of separate economic sectors, forecasting of specific activities and preparation of tactical plans. This attitude has being a basis for the methodology regarding prognostication of railway passenger transport volumes from a long-term perspective. Necessity of preparation of priority infrastructure projects and substantiation of their decisions determines the period of perspective.

It is necessary to carry out an analysis of transportation activity development and to formulate the projections of internal market perspectives and influences of external factors, seeking to accomplish prognostications of railway transport volumes from a long-term perspective. Since national economy has not yet overcome the consequences of economic crisis, the strategy of development of national economy and providences of perspective development of social sphere are not prepared. Our economic analysis is based on official macroeconomic indexes and projections of this year. One of the most important macroeconomic indexes, which indicate the level of development of national economy, is gross domestic product (further – GDP). GDP is a final market value of goods and services, which were created in a country per year. This index was used in forecasting of Lithuanian railway transportation volumes.

Basic presumptions for the recovery of economies of Lithuanian and other Baltic States are associative with global and international economical appearances. Economic recovery is possible only with global economic boom, also with the rise of our main export/import partners – European Union countries, Russia, Belarus, Ukraine, Kazakhstan and remote countries, international trade partners. Other presumption, necessary for economic development, is a recreation of the competitiveness of Lithuanian economy. For this purpose the decrease in production and products price is necessary. Unfortunately it is involved with a decrease in payments and real income per one household member. Those means can stimulate the deflation.

Since GDP includes consumption, investments, state expenditures, and export/import, both changes in economy, changes in social economic, attractiveness of business environment, investment guaranties and also implementation of decrease of state expenditure are important. Consequences of the recession of national economy firstly have influence on labour market, wages, and also the decrease of purchasing power and consumption.

Obvious marks of recovery of storage, transport, industrial production, retail sales allows looking to a perspective growth of national economy optimistically. Actually positive annual increment of GDP is affected by indexes of industry and transport sectors.

Accomplished analysis of projections and presumptions of basic macroeconomic indexes by official institutions and their analytics allows expecting a possible recovery of national economy during years 2010–2011 and climbing out of crisis situation. But the positive changes of social-economic indexes are expected to be slower and obtaining results later. Factual indexes of Statistics Department and the Ministry of Finance were taken as a base for the forecasting transport indexes.

Main Lithuanian railway transportations are connected to the cargo load of Klaipeda State Sea Port and Kaliningrad ports. Kaliningrad Sea Port is often used by local Lithuanian industrial companies for export of regular production and import of raw materials. Therefore the input of local manufacturers is getting more and more important, while they export bigger quantities of production.

Basic presumptions and conditions for increment of freight flows depending on local transportation, export and import, freight transit and composite transportation through the territory of Lithuania and other countries, were determined using an analysis of inside and outside factors influence.

Lithuanian Railway Company has a sufficient potential to transport increasing freight flows by the main European Transport corridors through the territory of Lithuania.

2. Singularities of Method Application

Determining problems of method application it is necessary to appeal whole complex of factors, which defines possibilities of simulated situation. Since substantiation of perspective projections is features of a current state and retro perspective development, full analysis of object activity and its changes is carried out. On the one hand, this is an analysis of quantitative change of main indexes, from the other hand – it is a qualitative analysis of their causality and consequences. Applying this principle of quantitative and qualitative development, in this case, for railway transport services, it is obvious, that quantitative changes of transportation activity indexes are analysed by adding qualitative analysis.

In order to research the perspectives of railway freight transportation, the analysis of retro perspective transport development was carried out. The duration of this analysis was defined by the period of convention of market economic relations, realization of strategic programs, introduction and convention of general EU market regulations.

It is recommended to divide the period of economic development of Lithuanian transport system and railway transport sector after the recovery of Independence as follows:

1991–1993. The economical and political reform in a country, economic transformation into market economy relations;

1994–2004. Market economic development before integration into the EU;

2004–2007. Positive development of Lithuanian social and economic sectors during the integration;

2007 (the 4-th quarter)-2010. Global economic depression, economic crisis in Lithuania.

In order to study a problem we recommend use coherent periods: 2004–2006 period of positive development and 2007–2010 period of crisis situation in a country.

Since the period of solid constant development should be longer than 3 years for the calculations of perspective projections, therefore we apply longer period for the analysis of economic development adding the period of preparations for the EU membership. Then recommended analysing period of positive development should be 2000–2006.

Although 2007–2010 economic recessions are considered to be a result of global crisis, each country has its own experience. Lithuanian economic endurance and preparation for such crisis appeared to be too small. Crisis consequences are still too heavy and must be restored into the pre-crisis state.

In order to repress crisis situation and to climb out of it applied economic and financial means helped to stabilize economic and social situation in 2010. Those means were common efforts of government, business and society to stop economic recession ant stabilize the development of economic and social sectors.

From the methodological point of view therefore economic activity results of transport sector and railway transport of 2010 (the 1-st and 2-nd quarter), also changes in macroeconomic indexes were included into the research. Stabilization and transition into the positive development of them are very important factors for the perspective projections. Only in the first quarter of 2010 the break in country economy noticed and defined also in transport service sector allowed to start perspective modelling of the activity. This modelling needs a new methodological attitude for the approval. This is a review of evaluation scale and a formation of new attitude.

From methodological point of view the activity of railway transport is analysed in the context of general transport sector and also separately examining certain activity of railway freight transportation, its results and dependency on inside and outside factors. In this way the recourse situation and the development of activity are evaluated [2, 3].

3. An Audit of Basic National Strategies

First of all it is necessary to conduct an audit of basic official strategies of analysed and perspective period. The aim of this audit is using new approach qualitatively evaluate main principals of development of National Economy, social sector and transport system, also railway transport, presented in basic strategies.

In this attitude it is necessary to formulate strategic aims and principals prolonging the operation of strategic documents into the post-crisis period, evaluating real situation and opportunities to implement determined important projects and programs.

This methodological move is necessary to be done because the period of recovery of National Economy takes 3–7 years for the negotiation of backwardness due to the complication of crisis consequences and also to the duration of social recovery which is longer that business recovery. Moreover, inertia is bigger in social economy. On the one hand, human resources as industrial factor has to negotiate economic challenges and recover their welfare, on another hand, inhabitants as goods and services users have to retrieve their purchasing power. Therefore the task of audit is very complicated and responsible.

Since perspective of development of National Economy is not accomplished, it is necessary to inventory strategic principals for this period.

Seeking to assess railway strategy and development trends, a review and analysis of existing long-term strategies was performed in the study. With the help of an audit, the most important strategies with relevant and realistically applicable propositions were selected. For this purpose basic long-term economic, transport and railway strategies, including important proposals and projections, are presented in this chapter.

A Complex Assessment of the Economic Situation of the Republic of Lithuania. The strengths of the national economy are related to: 1) successfully accomplished processes of economic transformation; 2) Lithuanian membership of the EU; 3) the process of economic internationalisation; 4) the geographical location of Lithuania; 5) the potential for technological progress; 6) developed physical infrastructure which is continually being modernized; 7) developed financial infrastructure which is continually being modernized; 8) restructured industrial sector which is continually being modernized; 9) favourable conditions for the development of agriculture; 10) geographically balanced distribution of large cities and smaller towns; 11) attractive environment and landscape, rich cultural heritage and abundant recreational resources; 12) large potential for development of higher education.

The weaknesses of the national economy are influenced by as follows: 1) the economic situations of western EU countries; 2) limitations on the main factors of economic growth and competitiveness; 3) not exploiting fully opportunities for foreign economic relations; 4) the shortage of physical infrastructure limiting economic growth and competitiveness; 5) the shortage of financial infrastructure limiting economic growth and competitiveness; 6) factors limiting industrial growth and competitiveness; 7) factors limiting agriculture growth and competitiveness; 8) factors limiting regional economic growth and competitiveness; 9) the lack of experience of economic development strategic management.

The opportunities of further development of national economy are related to: 1) wider opportunities for Lithuanian economic growth and competitiveness decided by the integration to the EU; 2) opportunities for Lithuanian economic growth and competitiveness decided by globalisation; 3) opportunities for Lithuanian economic growth and competitiveness decided by the science and technical progress;

4) opportunities for the development of physical infrastructure; 5) opportunities for the development of financial infrastructure; 6) opportunities for the increase of industrial development and competitiveness; 7) opportunities for the increase of agriculture and food industry development and competitiveness; 8) opportunities for regional economic growth; 9) opportunities for sustainable development assurance.

The threats to the national economy can include: 1) threats to Lithuanian economic growth and competitiveness decided by globalisation; 2) threats to Lithuanian economic growth and competitiveness decided by demographic situation; 3) threats to Lithuanian economic growth and competitiveness decided by the science and technical progress; 4) threats to the development of physical infrastructure; 5) threats to the development of financial infrastructure; 6) threats to industrial development and competitiveness; 7) threats to agriculture and food industry development and competitiveness; 8) threats to regional economic growth; 9) threats to sustainable development assurance [8, 10].

Key trends and measures of strategies used for the development of the national economy and transport directly depend on general national economic forecasts predicated on such important factors as the geopolitical and demographical situation of a country; social progress, environmental protection; the knowledge society; the level of economic development; the key factors of economic growth; the most important factors of economic competitiveness; singularities of the economic structure and regional economic development.

Conducting an audit of basic strategies allows the development of a plan for national economic development: 1) organize strategic processes of economic development; 2) pursue employment and social policy to stimulate national progress; 3) ensure further national integration and convergence with the EU; 4) stimulate competitiveness and improve other market mechanisms; 5) guarantee the stability of the national macroeconomic situation; 6) guarantee the development of human capital; 7) support scientific research, technological development and innovation; 8) improve the physical infrastructure; 9) create a business friendly environment; 10) create favourable conditions for foreign economic relations; 11) improve the national administrative capability.

The strategic objectives of Lithuanian economic development are as follows:

1. Develop and effectively exploit factors which would ensure fast and steady growth of economic and national competitiveness. This would help to create a knowledge economy in the country;
2. Promote the development of the national economy and its separate sectors. Structural economic reforms and national economic policy could allow faster improvements which could provide the necessary and sufficient economic conditions for social development, higher employment and environmental protection.

Key assumptions, strategic trends and suggested means for the development of transport sector. The role of Lithuanian transport systems is to ensure sustained mobility in society and the movement of goods, supporting the dynamic development of the national economy and to increasing the competitive potential of Lithuania and the expanded EU in international markets.

Existing economic analysis of the transport sector allows the following important objectives of the long-term development of the Lithuanian transport system to be defined

- achieve the transport service quality and technical parameter level of the old EU member countries;
- interact effectively with transport systems of neighbouring countries; become part of an integrated and important transport system link the Baltic Sea region (west-east);
- enable Lithuanian inhabitants to reach important cultural, tourist and commercial centres in Europe comfortably and fast;
- effectively to meet the interests of Lithuania and the expanded EU, increase its competitive potential in international markets.

From a long-term perspective, the Lithuanian transport system has to be developed considering national interests and the general tendencies of European transport development, and the needs of expanding markets. The conversion from modal (one transport mode) to intermodal (effective interaction of separate transport modes) transportation of both freight and passengers is one of the most modern trends in European transport development. The concept of intermodal freight transport can be practically realized by the development of transport nodes such as sea and river ports and inland logistic centres [10].

The key objectives of long-term development of railway and intermodal transport are as follows:

- modernize infrastructure, allowing effective integration into the EU transport system;
- create a substantial and effective traffic safety control system;
- accomplish reforms of the railway sector;
- resolve issues of community service obligation performance;
- create a common environmental protection system, covering all possible pollution sources (air, water, soil).

In order to successfully integrate into the structures of the European and Trans-European railway network, to realize high traffic speeds, to achieve maximum traffic safety, to meet EU requirements on environmental pollution, to ensure effective freight and passenger rail transport links between West and East, it is necessary to implement plans.

The Lithuanian Railway Strategic Trends and Methods up to the year 2030 is a realistic strategy which has already begun to be implemented. The adoption and realisation of this strategy was interrupted by the economic crisis. Specific factors must be reviewed and adjusted on the basis of forecasts up to the year 2040. The objective of the adjusted strategy is to ensure the competitiveness of Lithuanian Railways as the administrator of public railway infrastructure and logistic centres, and as the national rail transporter in the freight and passenger markets, and to ensure the financial stability of the company while maintaining high levels of traffic safety and environmental protection. For this purpose tasks are defined as follows:

- external factors and their influence on activity and development of the company;
- tasks and means to develop the company, relating to long-term investment programmes, funding requirements and obtaining financial resources;
- restructuring of the company, reforming the personnel policy, improving personnel capabilities, labour productively and efficiency.

Lithuanian Railways is the most important participant in the Lithuanian rail transport sector. It administers the public infrastructure: the existing rail network infrastructure, the new Rail Baltic infrastructure and the public logistics centres which are planned for construction in Vilnius and Kaunas railway stations. Lithuania Railways also manages freight and passenger transportation on railways and related economic-commercial activity [4,6,7]. It is predicted that Lithuanian Railways will be responsible for integrated national rail company activity and development as the administrator of public infrastructure and the rail freight and passenger operator during the prospective period up to the year of 2030.

4. Evaluation of Opportunities of Macroeconomic Growth

Conditions for economic development. The forecast for Lithuanian economic development is informed by current trends and assumptions regarding positive economic development: a sustainable fiscal policy, a stable monetary policy, an active labour market policy, and an investment and business motivation policy. After integration into the EU, Lithuanian economic progress was mostly linked with financial and other support from EU funds. The consolidation and acceptance of market relations accelerated the growth of economic development and also allowed improvements in social living conditions and the strengthening of the activities of key structures. The period of positive economic development up to the year 2008 can be characterized by new expectations of a higher quality of life for the country and for its inhabitants.

Key macroeconomic indicators, including GDP, were characterized by positive trends during the period of Lithuanian economic growth. The annual growth of GDP was positive also during the crisis period (Table 1).

Table 1. Key macroeconomic indicators of the Republic of Lithuania during the period of 2003–2009*

Indicators	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Real GDP growth, %	10,2	7,4	7,8	7,8	8,9	3,0	–14,8
Inflation (average annual), %	–1,1	1,2	2,7	3,8	5,8	11,1	4,2
Inflation (annual) , %	–1,3	2,9	3,0	4,5	8,2	8,5	1,0
Balance of current account, % share of GDP	–6,8	–7,7	–7,1	–10,6	–14,6	–11,6	3,8
Unemployment rate, %	12,4	11,4	8,3	5,6	4,3	5,8	13,7
Growth of export of goods, %	11,2	21,4	26,9	18,7	11,1	28,4	26,6
Growth of import of goods, %	7,1	16,8	25,5	23,5	15,4	18,0	38,2

*Source: Lithuanian Statistics Department

Tendencies and forecasts of prospective development. Further tendencies of social-economic development are related primarily to negotiating the next period of crisis (2010–2013). The projections made by the Ministry of Finance are progressively related to the recovery of economic activity related aspects of social life. This should require a longer period (Table 2).

Table 2. Key macroeconomic indicators*

Indicators	**Projections** (2010-05-07)				
	2009	**2010**	**2011**	**2012**	**2013**
GDP growth/chain-linked volume growth, %	-14,8	1,6	2,8	1,2	2,4
HCPI (average annual)/ Consumer price index,%	4,2	-0,1	1,5	2,0	2,5
HCPI (monthly annual inflation)/ Consumer price index, %	1,2	0,6	1,7	2,5	3,0
Growth of average monthly gross earnings, previous period = 100	95,4	94,7	100,6	100,9	101,9
Average monthly gross earnings, LTL	2052,4	1944,6	1957,1	1974,8	2011,5
Unemployment rate, % (according to labour force survey)	13,7	16,7	15,5	13,9	12,3
Balance of goods and services, % share of GDP	-1,1	2,8	1,7	0,2	-1,7
Growth of consumption / chain-linked volume growth, %	-13,3	-5,3	1,0	2,4	3,7
Growth of gross fixed capital formation / chain-linked volume growth, %	-39,1	15,1	14,1	2,0	5,0
GDP at current prices growth, %	-17,2	1,9	3,7	2,9	5,7

*Source: Statistics Lithuania

Three prospective scenarios are prepared: optimistic, basic (realistic) and pessimistic. The optimistic scenario – ***fast economic growth till the year 2040*** – forecasts fast and balanced growth of the Lithuanian economy, anticipating that the Lithuanian business, industry, agriculture and service sectors will climb out of economic stagnation, develop their activities without reducing production and produce better results in the international market. The general economic environment will eventually recover and it will be possible to produce an active development policy, whose implementation will result in hoped-for investment in the modernization of the economy, the application of new technologies and the development of manpower productivity. Economic growth will happen in a more balanced way, as a result of existing experience. Therefore economic overheat will be avoided and the business environment and social activity will be harmonized in the country and general market. More effective financial and market protectors are likely to be introduced.

The pessimistic scenario – ***slow economic growth till the year 2040*** – forecasts slower, but balanced growth of the Lithuanian economy, anticipating that a low average annual increase in GDP will be determined by low internal and foreign investment, extensive economic restructuring, and insufficient economic and political conditions for business development in the country. It is probable that a new economic crisis could have a critical effect on socio-economic development in this period. The experience of global economic development shows that the economic problems of separate countries or the groups of countries, international market stagnation, and problems with financial settlements can re-occur every 12–20 years even in periods of an active global economic market [11].

It is expected that an improved geopolitical situation, favourable financial conditions, flexible macroeconomic policy and the implementation of structural reforms will allow faster economic development of both Lithuania and the EU.

The realistic – basic GDP – scenario forecasts that GDP development should vary between the optimistic and pessimistic scenarios of economic development (Table 3).

Table 3. Basic GDP forecast, bill. LTL

Growth of Gross Domestic Product of Lithuania, billion LTL										
2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
92.37	94.77	96.48	98.89	101.57	104.67	124.00	153.09	186.14	224,.94	264.15

5. The Analysis of the Development of Railway Freight Transportation

5.1. The Analysis of Freight Transportation Activity

Main freight surface transportations are made by road and railway transport in Lithuania. Freight volumes transported by both transport modes are similar. Still railway transport having purpose to transport large amounts of freight for a long distance mostly maintains ports. Therefore Lithuanian railway freight volumes and their structure mostly are connected to cargo loads of Klaipeda State Sea Port and Kaliningrad ports. Also Lithuanian railways are often used by local industrial companies for export of regular production and import of raw materials. Therefore the input of local manufacturers is getting more and more important, while they export bigger amounts of production.

Basic economic activity – freight transportation – of JC “Lithuanian Railway” has met a crisis situation and recession in 2008. These changes are bigger than in load volumes of sea port.

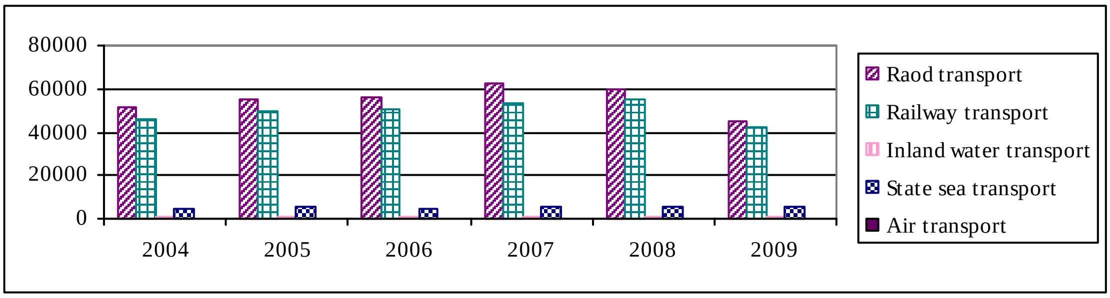


Figure 1. Freight transportations by various transport modes in Lithuania. 2004–2009

Table 4. Freight transportations by various transport modes, loads in ports, 2009

Transport mode	Index	Measure unit	Jan.-Dec. (Thousand)	December (Thousand)	Decrease, %, 2009. 01–12, compare to 2008.01–12	Increase, decrease %, 2009.12, compare to 2008.12	
						2008.12	2009.11
Railway transport	Freight transported	t	42 668,6	4 220,4	–22,4	3,3	6,0
	Freight turnover	t- km	11 887 811	1 192 885	–19,4	7,9	6,4
Klaipeda State Sea Port and Butinge terminal	Freight overload	t	36 173,0	3 304,0	–7,1	10,9	–1,1
	Overloaded	t	21 508,8	2 114,4	–3,2	25,7	8,8
	Unloaded	t	14 664,3	1 189,6	–12,4	–8,4	–14,9
Air ports	Freight overloaded and unloaded	t	7,2	0,7	–34,0	–29,0	–23,2
Lithuanian Air Company	Freight transported	t	2,9	0,3	–30,4	0,5	–9,6
	Freight turnover	t-km	1 632	196	–63,4	–43,7	4,9
Inland water transport	Freight transported	t	908,5	33,1	–8,1	–6,5	1,6

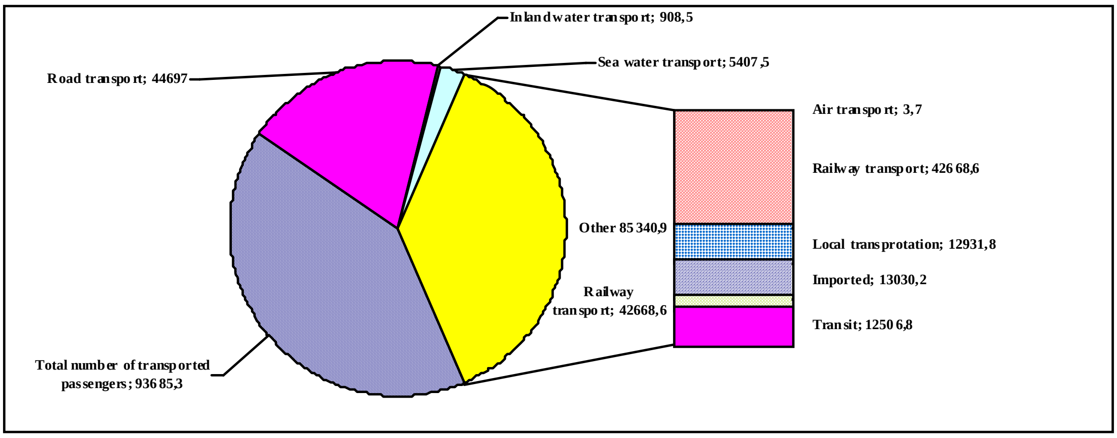
*Source: Lithuanian Statistics Department

JC “Lithuanian Railways” performs the basic passenger and freight transportations through the territory of the Republic of Lithuania. This company performs such activities as freight and passenger transportations, maintenance and development of technical infrastructure, traffic regulation, technical supervision and repair of rolling-stock and railway fleet and other related activities. This is one of the biggest company creating products, which can produce 1.4% of GDP during the period of economic boom.

Even in 2008, the beginning of crisis, this company earned about 1.6 bill. LTL, it was 14% more than in 2007, and the labour productivity increased about 11%. Freight transportations created about 86.1 % of total income. During 2009 transportation volumes decreased widely: freight transportation earned about 26.6% less than in 2008 though tariffs were not forced up. Passenger transportations created about 5.5% of total income. Since passenger volumes on local and international routes decreased, this activity created 3.9% less than in 2008. In order to compensate the lost income of transportation of preferential passengers and to indemnify the damages of passenger transportation on local routes governmental support about 5.0 millions LTL in 2009.

Basic activity earned the biggest part of income – 11,594 millions LTL in 2008 and 1,184 millions LTL in 2009. Financial, investment activities collected only small share of income. Other income collected from such activities as repair and technical supervision of rolling-stock, operations of locomotives and their crew in foreign countries, cleaning and storage of trains, other transportation services. These activities earned about 6.6% of total income in 2009 and it was 28,4% less than in 2008.

During 2009 about 42.7 millions tons of freight were transported by Lithuanian Railways and it was 22.4% less than in 2008 (about 55.0 millions tons). International freight transportations created about 29.7 millions tons and it was about 24.9% less than in 2008. Local freight transportations created about 12.9 millions tons and it was about 15.9% less than in 2008.



*Source: Lithuanian Statistics Department

Figure 2. Freight transportation by Lithuanian railway transport comparing with other transport modes. 2008–2009

The recovery of transport and storage sector connected to export-import activity observed at the beginning of 2010 as it was expected in providences of economic development. During January-April 2010 about 15.8 millions tons of freight were transported by Lithuanian railways, it was 21.5% more than during the same period 2009. During this period international freight transportations increased about 33.4% and it totally created about 12.1 millions tons. Local freight transportations decreased about 7.5% and it totally created about 3.7 millions tons.

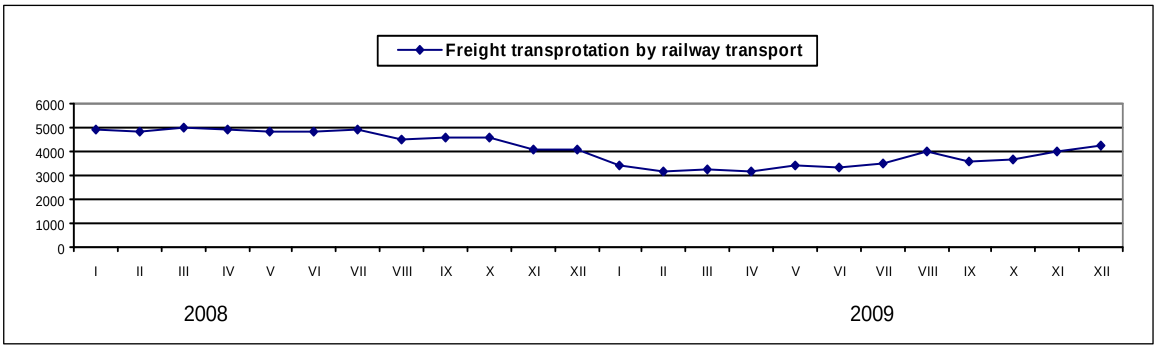


Figure 3. Freight transportation by railway transport in Lithuania. Distribution by months, 2008–2009

Freight transportation volumes and freight turnover depend on various factors such as volumes and structure of industrial and agricultural production, distribution of industrial forces and interregional connections, production supply, realization, organization and specification, quality of transportation planning, development of road infrastructure and freight distribution between various transport modes.

The structure of freight turnover has important influence on railway transport regarding configuration and truck load of rolling-stock fleet, average train weight, mechanization means of freight load, etc. Freight structure and transportation conditions have influence on cost and income calculation.

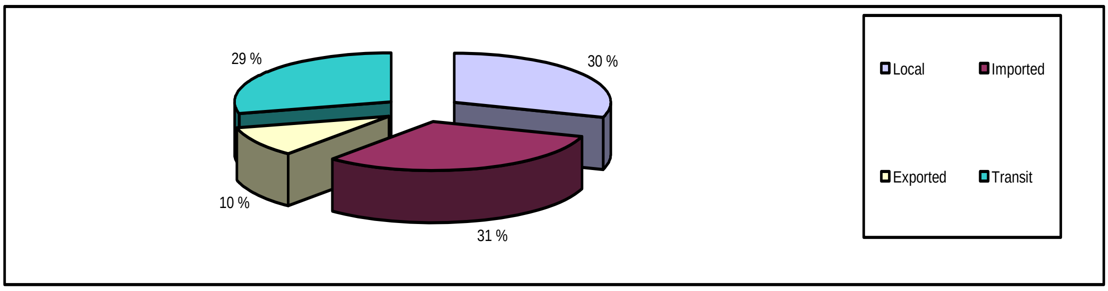


Figure 4. The structure of freight flows during 2009

During 2009 about 42.7 millions tons of freight were transported by Lithuanian Railways and it was 22.4% less than in 2008 (about 55,0 millions tons). The smallest share of total freight transportations was created by exported freights – 10% (about 4.2 millions tons), the biggest share – by imported freights – 31% (about 12.9 millions tons) and transit freights – 29% (about 12.5 millions tons).

5.2. The Trends of Lithuanian Railway Freight Transportation Activity

Basic freight volumes components and influencing factors can be determined as follows:

- ***Local freight transportation***. Local freight market is formed by:
  - the largest local companies – basic costumers;
  - changing structure of production and goods;
  - distribution of freight transportations between various transport modes depending on convenient access to railway lines and terminals, price of services and transportation distance.

During 2009 local routes transported about 12.9 millions tons of freight and it was 15.9% less than in 2008 (about 15,4 millions tons). Freights transported by local routes created about 30% of total amount of freights transported by Lithuanian Railways and it was 2% more than in 2008. Mostly petroleum and its products were transported by local routes – about 44.2% (in 2008 – about 40%) of total freights. Mineral products, ore, cinders transportations decreased about 57.4%.

- ***Freight export***. Freight export depends on:
  - potential and competitiveness of national industry;
  - a demand of exported production in foreign countries.

During 2009 about 4,2 mill tons of freight were exported and it was 29.3% less than in 2008 (5.9 millions tons). The biggest part of exported production (about 38.4%) consisted of petroleum and its products. The export of petroleum decreased about 0.7 million tons per year and it was 30% less than in 2008. The export of chemical and mineral fertilizers decreased about 53.4%; the export of wood, cork and their production decreased about 32.5%.

- ***Freight import***. Freight import depends on:
  - local demand of imported goods;
  - purchasing power of consumers.

During 2009 about 13.0 millions tons of freight were imported and it was about 16.2% less than in 2008 (15.5 millions tons). Imported freights created the biggest share (about 31.0%) of total freights transported by Lithuanian railways and it was 3.0% more than in 2008. The biggest share of imported freights consists of chemical and mineral fertilizers and petroleum and its products (about 32.5%). Petroleum products were imported 17.0%, ferrous metals – 60.3 % and mineral products – 42.9% less than in 2008.

- ***Freight transit***. Main freight transit directions are the following:
  - East-West link;
  - North-South link;
  - Economic dependence, geographical possibilities and political regulations of neighbouring countries to use Lithuanian transport infrastructure and services of logistics and transportation.

During 2009 about 12.5 millions tons of freight were transited and it was about 30.9% less than in 2008 (18.1 millions tons). Petroleum products composed more than a half of total transited freight (61.9%). Therefore transit or petroleum decreased about 14.9% (1.4 millions tons) and it was the base of decrease of total volumes of transited freights. About 6.2 millions tons of petroleum were transported to Kaliningrad and it was 19.5% less than in 2008 (about 7.7 millions tons).

- ***Multimodal transportations.***

Increasing popularity of container and composite transportations all over the world has influence on increase of container volumes in Lithuania especially in Klaipeda State Sea port. For this reason railways, sea ports and load companies of Lithuania, Belarus and Ukraine implemented project of composite transportation train "Viking" in 2003. Train "Viking" run on the route Klaipeda–Odesa–Klaipeda, but freights can be transported from West and North Europe to Belarus, Ukraine and also Turkey, Georgia and other remote countries of Caucasus. During 2008 about 34.0 thousand TEU containers were transported by this train. In 2009 volumes of containers increased about 16.2% up to 39.5 thousand TEU despite of general economic recession.

- ***Logistics centres.***

Developing intermodal transport in Vilnius (near marshalling-yard station in Vaidotai) and Kaunas, public logistics centres are being established. In order to use financial support of the EU Cohesion Fund necessary infrastructure will be created for these centres: modern intermodal surface terminal unique in Baltic States and East Europe will be constructed, good conditions for the flotation of companies operating in spheres of transport, logistics and other activity related to freight transportations will be created. It is expected that this conception will stimulate commercial cooperation between various transport modes and therefore bigger volumes of freights will be transported by railway transport – more economic and ecologic transport mode.

5.3. Evaluation of Influence of Internal and External Factors

Internal Factors depends on initiatives and competence of JC "Lithuanian Railways" and can be defined as follows:

1) Development of the potential necessary to ensure freight transportation activity – sufficient rolling-stock fleet, capacity of railway infrastructure (lines, stations), enlargement of potentials of freight terminals.
2) Enlargement of efficiency of freight transportation activity (to minimize freight transportation costs, ensuring high quality of services in order to apply competitive tariffs).
3) Assurance of service quality meeting needs of customers, development of the scope of related services, enlargement of service availability (this will succeed constantly improving costumers' satisfaction with service quality and price, developing the scope of necessary additional services, improving service availability).
4) Assurance of effective partnership with Klaipeda State Sea Port and load companies.

External factors have influence on intercourse and cooperation with foreign railways and other economic subjects participating in common logistics network ensuring permanent business intercourse and benevolent relations. The great role falls on effective cooperation of the Company with:

- Belarusian railways, which mostly are intermediate, link for freight transportations from CIS and Asian countries to Lithuania and also for local production transportations to CIS and Asia countries.
- Polish railways, which are intermediate, link for freight transportations on I Transport Corridor (Rail Baltica line).
- Kaliningrad railways, which work efficiency has influence on the efficiency of basic segment of freight transportations by Lithuanian Railways – freight transit to Kaliningrad direction.
- Latvian railways, which are important for the development of freight transportations on I Transport Corridor (Rail Baltica line).
- Expeditionary companies, which decisions usually have influence on freight transportation ways and directions.

6. Assumptions for the Growth of Freight Transportation by Railways

Assumptions for the growth of railway potential are as follows:

1. Technical improvement and modernization of railway infrastructure meeting AGC and AGTC requirements in regard to assuring occupational safety and environmental protection.
2. Integration into the Trans-European networks; implementing necessary junctions and avoiding narrow sites on the main I and IX railway corridors through the territory of Lithuania.
3. Renovation, modernization and development of rolling-stock and vehicle fleet; increasing their capacity and competitiveness.
4. Implementation of railway sector restructuring and personnel training to enable new activities of the company.
5. Implementation of the EU directives on railway activity and other legislation seeking to liberalize railways and enter into the European transport sector market.

Factors enabling the growth of rail freight flows are as follows:

1. The progress, potential and competitiveness of the Lithuanian economy, its ability to climb out of the current economic crisis and its continuing development.
2. The capability of separate economic sectors and big organisations to perform in market economic conditions despite the economic reforms, company restructuring, changes in the lifestyle and variations in the international market affecting results.
3. Consolidation of human capital in the context of socio-economic challenges.

4. Liberalization of the business, industrial and service sectors, consolidation of social structures, harmonization of business activity and social indicators, implementing the Lisbon Strategy and policy objectives.
5. Opening of industrial and consumer markets, opportunities for qualitative and quantitative development in the EU countries, opportunities to develop international trade and to integrate into the global economy.
6. Implementation of new lifestyle models and new conceptions of social values, promoting good practice in the social sphere while meeting the new demands and expectations of the modern population, which are the result of integration into the western market economic system.
7. Promote new economic relations with redeveloping countries (Russia, Ukraine, Moldavia, Kazakhstan, Uzbekistan, and other Caucasus and CIS countries), whose goods and freight flows are often transported through the territory of Lithuania. This could be the basis for further development.
8. Integration of eastern neighbouring countries into the World Trade Organization must be the starting point for international cooperation in the railway sector. This will include agreements about tariffs. A recovery in consumer demand and purchasing power is likely to stimulate Lithuanian exports.
9. Governmental targets and efforts to initiate economic cooperation, participate in joint projects with remote Asian countries and unite markets create the economic situation in which the prospects for international trade and transportation can be viewed.

Since potential of JC “Lithuanian Railways” to transport freight volumes was sufficient during pre-crisis economic development, it is predicted further gradually modernize and develop this potential according to increasing demand. ***Perspective development of freight volumes*** is motivated by 4 basic providences:

1) Quantitative increase of freight flows in volumes of positive pre-crisis development and further quantitative increase due to economic growth of Lithuania and neighbouring countries are possible and expected.
2) Due to active international marketing of the Company and qualitative changes in economies of countries and freight formations the increase of freight volumes on railways is expected together with redistribution of sphere of influence in the market and activation of transportation development increasing competitiveness of separate economic blocks.
3) The increase of freight volumes for railway transport due to faster result of their transportations comparing to transportations by marine transport.
4) Retrieval of a share of freights transported by rod transport due to faster border crossing transporting freights through the territories of several countries and also due to overloaded road transport highways and difficult traffic conditions including seasonal and climatic disturbances on long-distance trips.

In any case the success of implementation of Companies’ strategy mostly will depend on marketing and organizational efforts. The potential will depend on investment programmes and projects for the modernization of railway transport and the support of its’ competitiveness.

7. Prognostication and Projections of Freight Transportation Volume

The analysis of markets of interest spheres is carried out methodologically details:

- from one hand, the analysis of main markets of countries situated on basic directions of Trans-European corridors and international trade opportunities, transport relations realizing by railway transport;
- from other hand, the analysis of traditional and new interests of other countries to use Lithuanian railways, new transport projects usually depend on political decisions of countries belonging to different economic blocks, quickness of market development, participation in international organizations, stability of local political powers and other members of macro-economy.

Therefore detailed analysis of opportunities of post-crisis recovery of markets of neighbouring and remote countries and economic growth was carried out. Also the evaluation of increase of interest of remote countries and opportunities of their geographic development and also influence on global and international transport development was carried out.

Analysed potential of economic markets on I and IX railway Trans-European corridors is sufficient base for prognostication of existing freight flows through the territory of Lithuania to and from countries participating in transportations:

- ***from a short and middle –term perspective*** – quantitative increase of freight flows due to better conditions of the markets and their development influenced by recovered and increasing international trade;
- ***from a middle and long-term perspective –***
  - qualitative changes of freight structure due to the restructurization of economics of neighbouring and remote countries or new production in primary industry, agriculture and services.
  - qualitative or technologic changes of freight structure due to the implementation of modernization projects of neighbouring and remote countries and the development of potentials of railway operators, the implementation of multimodal technologies.
- ***from whole perspective –***
  - the development of possibilities of changing structure and transportation of increasing freight volumes due to the development of load capacity in Klaipeda and other possible sea ports of Lithuania;
  - the development of possibilities of transportation of increasing freight volumes due to the development of infrastructure and capacity in logistics centres of Kaunas, Klaipeda and Vilnius (change of transport mode and technologies).

Three scenarios of perspective projections were defined after the evaluation of analysed assumptions and providences, internal and external factors and their possible influence. Basic scenario can be characterized by features of moderate development and results of activity of Railway Company:

1. Infrastructure projects supported by the EU financial funds are implemented progressively;
2. Railway transport will strengthen its positions in local transportations due to the implementation of marketing means;
3. The rolling-stock will be modernized progressively;
4. Investment for the increase of traffic speed and safety will be moderate and progressive;
5. Rail Baltica project will be implemented without expected high speed;
6. New and larger freight volumes will be formed implementing Rail Baltica project only to Kaunas terminal;
7. The importance of railway transport and its' share in general freight transportations and not only on Trans-European corridors will increase due to the lack of capacity of road transport highways;
8. Development and modernization of Klaipeda State Sea port will have moderate influence on increase of railway freight transportations, improvement of transportation technologies, modernization of its' potential;
9. Due to the electrification of main railway lines, traffic speed will be higher (but will not reach strategic speed) and will improve links with railway networks of other countries increasing the attraction of Lithuanian railway services;
10. Freight flows formed by other countries increasing freight transit and import and accepting export from Lithuania will have positive development. Their influence will depend on specific opportunities of market development and acceleration.

The prognostications of main freight flows transported through the territory of Lithuania calculated according definite methodology are optimistic and present recovery and development of economies of Lithuania and neighbouring countries.

The scale of production will expand due to new wider markets and the influence global processes and international transportation. Table 4 shows the forecast for common freight flows on Trans-European railway corridors up to the year 2040 [11].

Table 4. Forecast of common freight flows on Trans-European railway corridors till the year 2040, mill LTL

Forecast of freight flows	2010	2015	2020	2025	2030	2035	2040
IX railway corridor	28,2	35,0	42,4	48,0	55,4	62,7	66,7
I railway corridor	2,3	3,1	5,6	7,1	9,0	11,5	13,4
Inland transportation	12,3	15,8	20,6	26,8	34,5	47,7	12,3

Conclusions

1. The analysis of the development of Lithuanian Railway freight and passenger transportation activities, the development and management of its infrastructure and other aspects shows that the company is in a position to develop its potential during the period of restructuring.
2. Proceeding with the key modernization programmes and investment projects of the Company there are priorities of national significance, and form a part of the development of the EU transport system. The implementation and modernization of infrastructure, the renovation and modernization of the traction and rolling-stock fleet, improvements in traffic control and assurances of traffic safety, and the installation of new technologies in the area of property and management are important steps which receive strategic investment.
3. In order to analyse long-term development strategies for the national economy and in the social sphere, long-term development strategies for the transport sector, strategies and forecasts of railway transport development including strategic objectives and providences are applied. However, forecasts must be adjusted due to the economic crisis and its effects, which must be considered in new projections of macroeconomic indicators.
4. Since the economic crisis is global, embracing neighbouring and remote countries, and its effects on transporting freight and passengers within the territory of Lithuania are not known, it is necessary to adjust existing forecasts of railway transport activity for the prospective period after 5 years.
5. The usual EU methodology was used to forecast macroeconomic indicators and rail freight and passenger volumes up to the year 2040. Optimistic (successful), basic (realistic) and pessimistic (minimalistic due to failures in the progress) scenarios were presented. The realistic scenario is expected to show variations between the extremes of the optimistic and pessimistic scenarios of economic development.
6. Assumptions of key internal factors are as follows: 1) the readiness of the company to develop its activity potential; 2) positive and developing activity of local consumer market, increases in exports; 3) increases in international freight volumes during the period of economic growth; 4) the recovery of economic relations with foreign countries; 5) focusing on recovery and the stimulation of passenger transportation activity.
7. Assumptions of key external factors are as follows: 1) global climb out of the economic crisis; 2) recovery of former routes and volumes of freight transportation; 3) qualitative changes in separate countries' economies and in the economies of groups of countries, changes in the structure of goods and freight; 4) reforms of influence zones, penetration into new markets on a regional, continental and global scale; 5) increase in the competitiveness of Asian, European and American countries and groups of countries; 6) a positive balance in the development of the global business environment (information technologies, financial systems, business relations and organization) and coordination opportunities with countries that are members of separate economic unions.
8. Forecasts of freight transportation on Lithuanian railways up to the year 2040 have been made for lines of 1 and 9 corridors, including freight volumes for separate countries and groups of countries, which transport export and import freight and transit freight on the territory of Lithuania. These forecasts have been made in relation to local market, international and regional rail freight transportation, and detailed for separate sectors (hubs) and opposite directions of movement.

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LIGHTNING STROKE PASSIVE LOCATION BY ATMOSPHERICS ANALYSIS IN THE HOP MODEL FRAMES

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The problem of lightning location from single station observation is considered based on the hop model of lightning electromagnetic radiation pulse propagation in spherical waveguide "Earth – ionosphere". Some new methods are discussed to estimate the delays of the ionosphere reflected waves with respect to the ground wave. These delays give raise to the undetermined system of equations where unknown quantities are the distance and the effective reflecting heights of ionospheric waves. Some methods to remove the uncertainty based on approximation of difference of effective reflecting heights are considered. Program codes in Matlab to process atmospherics are developed. Proper examples concerning of really registered signals are carried out.

Keywords: thunderstorm, lightning, electromagnetic radiation, atmospherics, hop model, ionospheric waves, delays, distance evaluation

1. Introduction

Lightning discharges are significant causes of interruptions or damages in almost every from earth-based structures, especially electrical or electronic systems that are exposed to influence of thunderstorms. Damages and interferences in the ground structures are caused by cloud-to-ground lightning strikes mainly. The problem is particularly severe for electric power lines, fuel or gas pipelines utilities that have exposed assets covering large areas. The lightning induced mine explosions are in this list too. In addition, cloud-to-ground lightning discharges give rise to significant part of forest fires (up to 70% in poor populated territories), so as the primary hazard is forest fires inflammability detection.

Cloud-to-ground discharges make up a third of all lightning strikes: the remaining two thirds occur within clouds or between clouds. The cloud-to-cloud discharges can provoke numerous faults in airplane body and avionics. Important role in it belongs to secondary side-line effects of lightning appearance, including severe air turbulence, heavy hail and/or shower, and electromagnetic radiation, rather than the direct lightning strike into fuselage itself.

Thus, detection and location of lightning discharges are the serious scientific and technical problems. Appropriate technical systems would be based on passive location principles, namely, receiving and processing of atmospherics, or transient pulses created by intrinsic electromagnetic radiation of individual lightning channel.

There are two ways to decide this problem. The first is to develop a network consisting of great number of receivers, data transmission lines and common processing centre. During 1980–1990 the Lightning Detection Networks (LDN) have been created in some economically powerful countries (USA, Austria, England, for example). The network consisting of 200 receiving stations evolves in China started from 2008.

LDN operational principle is based on measurements of the "times of arrivals" (TOA) of atmospherics to the different receiving points whose geographic coordinates are fixed. Then, differences of TOA are calculated and solutions of so-called inverse geodesic problem are found resulting the lightning discharge coordinates.

Proper scheme is shown on Figure 1 [1] where the ciphers designate accordingly:
1) receiving sensors transmit data to satellite; 2) satellite relays information to Earth station; 3) data is transmitted to processing centre via landlines; 4) this centre processes data; 5) processed data relays back to satellite; 6) lightning discharge data is displayed within few seconds after the strike. Receiving sensors are marked with white dots on US map showed on Figure 1. The sensors in LDN are typically separated by 50–400 *km*.

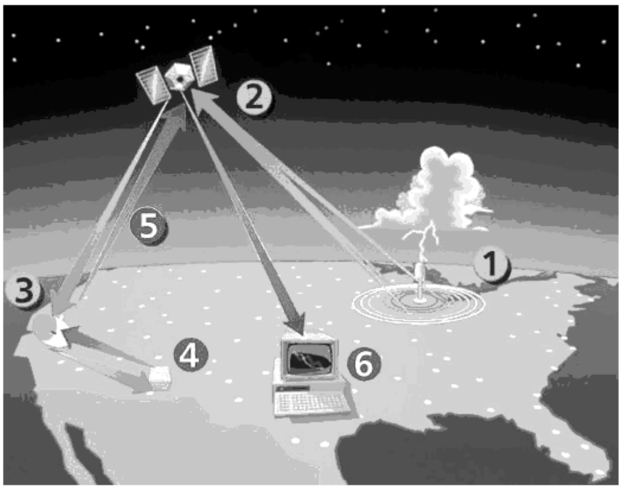

Figure 1. Operational principle of LDN

The alternative way is the system for lightning location from single station observations. The bearing indication on to the lightning discharge is decided by processing of the individual atmospherics based on direction finding methods. The main problem is evaluation of the distance from the discharge. It can decide based on the certain inherent features extracted from the atmospherics. The latter propagates in Earth-ionosphere waveguide, therefore, these features are reflected the properties of that trace.

With rigorous mathematic point of view, evaluation of the distance is covering the functional operator reflecting the space of atmospherics generated by lightning with the same distances and received by the same sensor to the same quantity. All the methods of single-point distance evaluation can be divided into two groups. First of them include “local” methods where estimation of distance is formed from the quantity of signal in neighbourhood of some characteristic point (as maximum amplitude of the temporal form or maximum spectral density of atmospherics). Fatal shortcomings of these methods are dependence from magnitude and kind of the current in the lightning channel. Nevertheless, the local methods put into the operational principles of devices adopted for ground [2] and airborne [3] applications.

2. Hop Model

The second group consists of “integral” methods where the distance estimation is calculated by analysis all the atmospherics temporal form. If the distance from lightning discharge to receiving point is not larger than 1500–1800 *km*, a hop model of atmospherics propagation in spherical Earth – ionosphere waveguide would be discussed. It is supposed the received atmospherics consists of superposition from a ground wave and some waves reflected by ionosphere. The inherent features of the appropriate distance in this case should be appeared as delays or times of arrivals (TOA) of that reflected waves.

The 2-hop model sketch is illustrated on Figure 2. Electromagnetic radiation initiated from point A propagates to receiving point B in a spherical waveguide. The lower wall of it is surface of the Earth, and the upper wall disposes within D-layer (day time) or E-layer (night time) of ionosphere. Receiver in B registers the process of interaction of the ground wave $E_g(t)$ passed the distance r_0, and a few ionospheric waves. Only two waves from them are shown on Figure 2. The single-hop wave $E_{i1}(t)$ and twice-hop wave $E_{i2}(t)$ pass the ways signed as r_1 and r_2 being reflected from the effective heights H_1 and H_2 with angles θ_1 and θ_2 accordingly.

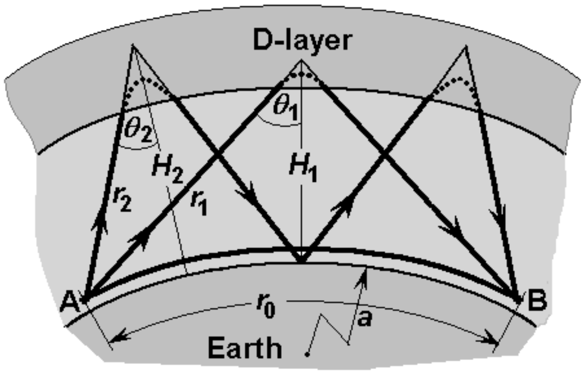

Figure 2. The hop model of the ionospheric waveguide

The input signal of receiver can be written as

$$u(t) = E_g(t) + \sum_{n=1}^{N} E_{in}(t) = I(0,t) * [h_c(0,t) * h_g(t) + \sum_{n=1}^{N} h_c(\theta_n, t) * h_{in}(t)], \qquad (1)$$

where sign $*$ is a symbol of convolution, $I(0, t)$ is temporal form of the current pulse in lightning channel base; $h_c(\theta, t)$ is pulse function of lightning channel radiation to the direction setting by angle θ, $h_g(t)$, $h_{in}(t)$ are pulse functions of traces for ground wave and n-th ionospheric wave accordingly. Evidently, the reflected waves $E_1(t)$ and $E_2(t)$ are delayed versus ground wave by times signed further as τ_1 and τ_2 correspondingly.

From geometrical properties of the waveguide one can obtain the system of equations,

$$T_n = (1 - 2Z_n \cos R_n + Z_n^2)^{1/2} - R_n, \quad n = 1, 2, \ldots \qquad (2)$$

where $T_n = c\tau_n/2na$, $R_n = r_0/2na$, $Z_n = 1 + H_n/a$ are normalized delays, distances and effective reflection heights accordingly; c = 2,998·10^8 *m/sec* is light velocity in vacuum, a = 6378 *km* is radius of the Earth.

As the two-hop model is considered the system (2) consists of two equations, but three unknown quantities are in it, namely, the distance and ionospheric waves effective heights of reflection. Therefore, this system is undetermined since the number of equations is lesser on 1 than the number of unknown quantities. Some possibilities to expand the system will be examined later.

3. Evaluation of Delays

Signal (1) under consideration has formed by convolution. As an example, Figure 3 at the top shows the atmospherics registered in daytime by a certain sensor belonged to LDN. The distance from lightning was estimated near 600 *km*. It is obvious that visual identification of separate waves in this signal is most likely impossible.

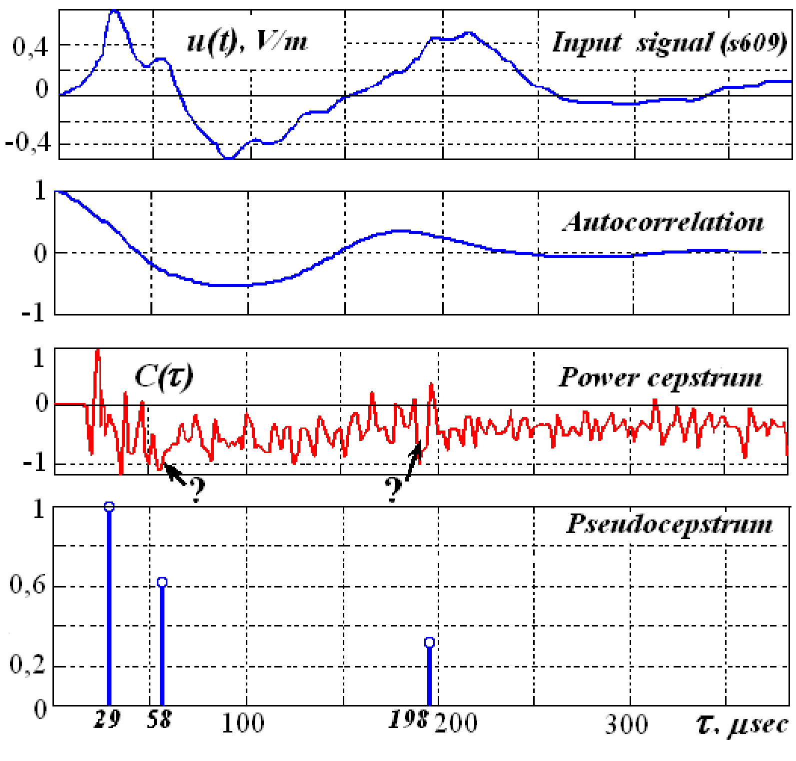

Figure 3. Atmospherics and some results of processing of it

Collection of methods to estimate delays of internal structural components in that signals is rather poor. A common way used is to calculate the autocorrelation function based on Fourier transformation (FT) as follows [4]:

$$\mathrm{ACF(t)} = \mathrm{FT}^{-1}\{|\mathrm{FT}[u(t)]|^2\}, \qquad (3)$$

where FT^{-1} is a symbol of inverse Fourier transformation. The function (3) is illustrated as the second row of Figure 3. Estimation of delays from it is rather impossible too. Perhaps, it can be explained by sufficient differences in the forms of ground and ionospheric waves.

As a signal corresponds with the convolutional model one can attempt to estimate delays applying the cepstrum analysis [5]. It is conceptually based on three steps:

(a) calculation of direct FT to find the signal complex spectrum $S(\omega)$;
(b) calculation of the logarithmic spectrum $S_{\log}(\omega) = \log S(\omega)$;
(c) calculation of inverse FT from $S_{\log}(\omega)$.

Combining these operations we can obtain the following:

$$c(\tau) = \mathrm{FT}^{-1}\{\log(\mathrm{FT}[u(t)])\}. \tag{4}$$

The result (4) is known as the complex cepstrum of the signal $u(t)$. The values assigned as τ are named quefrencies. Physically, anyone from quefrencies has a meaning as some delay. In many cases it is sufficiently to operate with power cepstrum

$$c_p(\tau) = \mathrm{FT}^{-1}\{\log(|S(\omega)|^2)\} \tag{5}$$

or real cepstrum only neglecting by phase information, which is contained in the complex spectrum $S(\omega)$ or logspectrum $S_{\log}(\omega)$ [5].

It is known that cepstral algorithms are worked satisfactorily for the linear models only, as long as convolutional components of signal are mapped onto logspectrum additively. Moreover, they run successfully if the next conditions are kept: (i) signal has sufficient duration; (ii) inherent structure of it is periodical; (iii) signal-to-noise ratio is sufficiently large. As a rule, atmospherics are incompatible with conditions (i) and (ii). The third row in Fig. 3 shows the power cepstrum of the analysed atmospherics. It is seen that estimation of delays from cepstrum in this case is actually impossible.

It would be supposed that considered methods works unsatisfactorily owing to the FT, as a mathematical operation, possesses certain lacks itself. Particularly, it is known that FT is not incompletely adequate for non-stationary signal processing [4, 5].

We have been investigated the methods to expose the inherent structure of lightning electromagnetic radiation. One from them is considered in [6] founded on computing of adiabatic invariants of atmospherics. We have been proposed also the new, non-Fourier method for estimation of delays which was published [7] as pseudocepstral analysis.

The algorithm based on Huang-Hilbert transformation [8] of logarithmic spectrum $S_{\log}(\omega)$ is expounded in detail in [7]. The result of it is illustrated in a lower row of Figure 3. The calculated quantity is named pseudocepstrum. The δ-pulses positions showed on this plot are equivalent with quefrencies in (5). The signs of the pulses are ignored owing to neglecting of phase information. The pulses indicate consequently the following moments:

1) the electric current pulse propagating along lightning channel is reached the top of the channel; electromagnetic radiation from the channel is ended;
2) one-hop ionospheric wave is arrived to the observation point;
3) two-hop ionospheric wave is arrived.

Proceeded from these data, the inverse problem concerning geometry of waveguide Earth – ionosphere would be decided. It is important contribution to theory of single-station lightning strokes passive location on the basis of the own EM radiation analysis.

4. Evaluation of Distance and Effective Heights

After estimation of delays it should be reverted to the system of equations in (2). Unknown quantities in it are the distance and effective reflecting heights of ionospheric waves. As it was mentioned the system is undetermined. We have been investigated some methods to find additional conditions closely linked the unknown quantities.

One possibility is based on approximation of difference of effective heights having considered as the function of the distance r_0. To build that function it is necessary to know how electron density N_e and collision frequency ν_e of ionosphere change versus heights. The exponents are supposed frequently in theory but it requires special analysis. These parameters depend on daily-times and geographic positions of atmospheric propagation traces. That is why using of this method in practice is rather doubtful without *a priori* knowledge concerning ionospheric parameters and needs in additional examination.

It is desirable the method of elimination of defects in (2) is not linked with N_e and ν_e characteristics. The corresponding algorithm for estimation of distance r_0 and heights H_1 and H_2 is offered below. It is based on some restricts for solutions of (2) which follow from physical consideration of propagation in Earth – ionosphere waveguide:

1) reflecting heights lie within D-layer in daytime or E-layer in night time then

$$H_0 < H_n < H_{D,E}, \qquad n = 1, 2, \ldots \tag{6}$$

where $H_0 \approx 60$ *km* is the height of lower boundary of ionosphere, $H_{D,E}$ is the height of upper boundary of D or E-layer, *n* is multiplicity of reflection;

2) as that multiplicity grows the effective heights increase, and thus

$$H_{n+1} > H_n; \tag{7}$$

3) as it has to follow from the Fermat principle, every ionospheric wave passes that way which is minimized for the time of passing. Therefore, the true distance r_0 has to conform to minimum positive difference of heights H_{n+1} and H_n, that is

$$\min(H_{n+1} - H_n) > 0. \tag{8}$$

Joining (6)–(8) one can obtain the additional condition to select only that result from a set of solution of the undetermined system (2) which answers the demand

$$\hat{r}_0 = r_0 \Big|_{\min(H_{n+1} - H_n) > 0,\ H_0 < H_{n+1,n} < H_{D,E}}, \quad n = 1,2,\ldots \tag{9}$$

Initialisation of the algorithm using (9) is illustrated on Figure 4. It demonstrates some dependencies of delays from distance r_0 and effective reflection heights. The D-layer is considered where these heights are from 60 to 80 *km*. Upper field is conformed with double reflected wave, as lower field illustrates possible delays region for single reflected wave. Finding the values τ_1 and τ_2 from analysis of the atmospherics and setting these values into equation (2) together with mentioned values of heights one can obtain the estimations both minimal $r_{0\,min}$ and maximal $r_{0\,max}$ distances, which correspond to these delays. The difference $r_{0\,max}$ - $r_{0\,min}$ is the range for finding the true value of r_0.

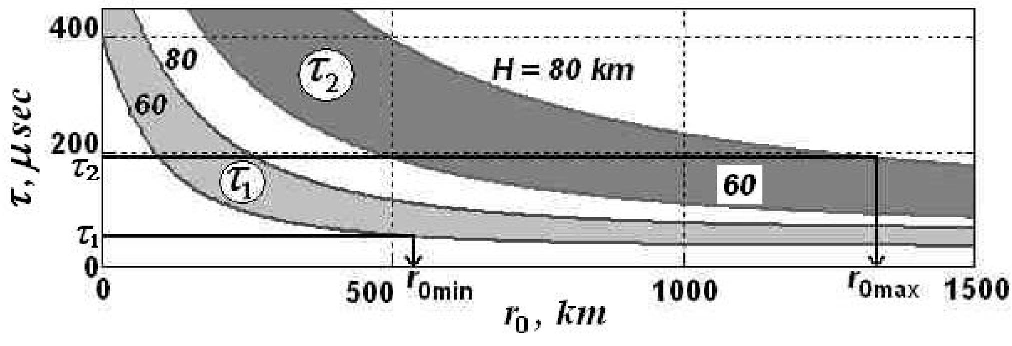

Figure 4. Initial step to start the algorithm (9)

In order to narrow this range the *m*-iteration procedure is introduced as follows.

$m = 1$:

a) Substituting τ_2 and $r_{0\,min}$ into (2) one obtains the new value H_1.
b) By analogy, from τ_1 and $r_{0\,max}$ it is obtained the new value H_2.
c) Then, substituting τ_1 and new H_1 into (2) one obtains the new value $r_{0\,min}$.
d) By analogy, from τ_2 and new H_2 it is obtained the new value $r_{0\,max}$.
e) If $H_2 - H_1 > 0$ and simultaneously $r_{0\,max}$ - $r_{0\,min} > 0$ it has to set $m = m + 1$ and has to repeat these steps from a) to e) and so on.

Stopping criterion is failure of one or both from inequalities in the stage e).

Experiments with this algorithm demonstrate sufficient rate of convergence as it is shown on Figure 5 for the same daytime atmospherics considered before. It is seen the result has been attained during 5 iterations only.

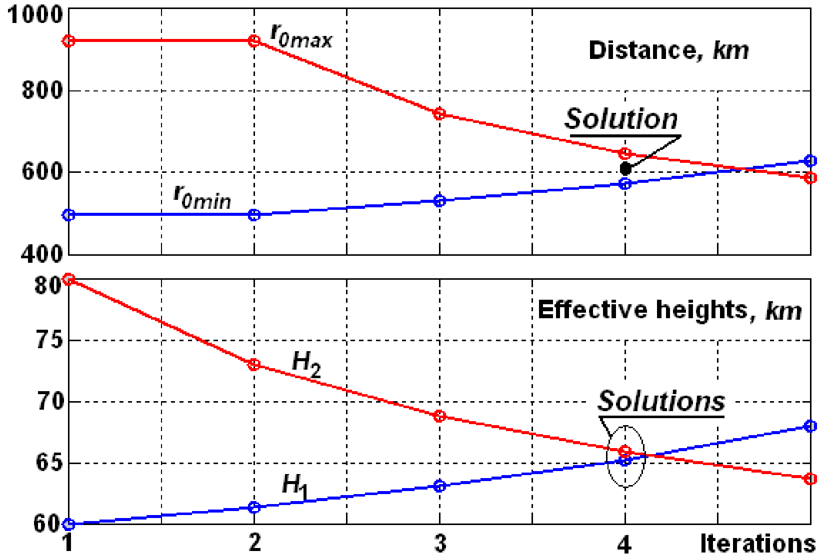

Figure 5. Convergence of the algorithm (9)

As the true value r_0 it is accepted the mean from $r_{0\ max}$ and $r_{0\ min}$ is reached during iteration which is preceded to the stopping. The same iteration determines the solutions of the system (2) for the effective heights H_1 and H_2.

Conclusions

In this research the hop model of propagation of electromagnetic pulse generated by lightning discharge in Earth – ionosphere spherical waveguide is considered. It is ascertained the methods for evaluating of delays of ionospheric waves from atmospherics based on Fourier transformations are non-adequate more often. As an alternative, the pseudocepstral method using Huang-Hilbert transformation is proposed to estimate these delays.

Proceeded from the values of delays, inverse problem concerning geometry of waveguide Earth – ionosphere would be decided with the help of the undetermined system of equations (2). The algorithm of solution eliminating the uncertainties without handling of the data about ionospheric layers parameters is worked out. Both the distance from the lightning discharge and the ionospheric heights can be estimated by a few iterations. It may seem as important contribution to theory of single-station passive location of sources of electromagnetic radiation propagated in ionosphere. All the procedures described above have been realized in Matlab. It is supposed the future works should be devoted to mass processing of atmospherics in order to establish statistic characteristics and precision of that algorithm.

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SIMULATION AT THE BRATISLAVA AIRPORT AFTER APPLICATION OF DIRECTIVE 2009/12/EC ON AIRPORT CHARGES

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The Directive on Airport Charges-Directive 2009/12/EC was issued in March 2009 by European Parliament and the Council. It is a common framework regulating the essential features of airport charges. EU presents the necessity of economic regulation of airports and airport charges in Europe, but is the economic regulation the right way for Bratislava Airport and airports in the similar position? This paper explains the situation of Slovak airports and their approach to economic regulation of airport charges. The paper describes the simulation of situation at the Airport Bratislava after application of a regulation formula of economic regulation of airport charges considered as the most appropriate for Slovak airports especially Airport Bratislava. The regulation formula is based on the research of the authors.

Keywords: directive of EU, airport charges, simulation, regulation formula, Slovak airports

1. EU Directive on Airport Charges

This paper focuses on economic regulation of airports in the Slovak Republic after the introduction of Directive 2009/12/EC (‘the Directive’ hereafter) on airport charges. EU recommends regulating airport charges of 69 European airports. In order to do that, it was necessary to establish a common framework regulating the essential features of airports charges and the way they are set, as in the absence of such a framework, basic requirements in the relationship between airport managing bodies and airport users may not be met. Such a framework should be without prejudice to the possibility for a Member State to determine if and to what extent revenues from airports’ commercial activities may be taken into account in establishing airport charges. The Directive sets common principles for the levying of airport charges at Community airports. It shall apply to any airport located in a territory subject to the Treaty and open to commercial traffic whose annual traffic is over five million passenger movements as well as to the airport with the highest passenger movement in each Member State which enjoys a privileged position as a point of entry to that Member State. It is necessary to apply the Directive to that airport in order to guarantee respect for certain basic principles in the relationship between the airport managing body and the airport users, in particular with regard to transparency of charges and non-discrimination among airport users. The ICAO Council has considered that an airport charge is a levy that is designed and applied specifically to recover the cost of providing facilities and services for civil aviation, while a tax is a levy that is designed to raise national or local government revenues which are generally not applied to civil aviation in their entirety or on a cost-specific basis. Airport charges should be non-discriminatory.

The Directive stipulates that a compulsory procedure for regular consultation between airport managing bodies and airport users should be put in place with the possibility for either party to have recourse to an independent supervisory authority whenever a decision on airport charges or the modification of the charging system is contested by airport users. In order to ensure impartial decisions and the proper and effective application of the Directive, an independent supervisory authority should be established in every Member State. Member States shall guarantee the independence of the independent supervisory authority by ensuring that it is legally distinct from and functionally independent of any airport managing body and air carrier.

Further, it is vital for airport users to obtain from the airport managing body, on a regular basis, information on how and on what basis airport charges are calculated. Such transparency would provide air carriers with an insight into the costs incurred by an airport and the productivity of an airport’s investments. To allow an airport managing body to properly assess the requirements with regard to future investments, the airport users should be required to share all their operational forecasts, development projects and specific demands and suggestions with the airport managing body on a timely basis. Member States shall take the necessary measures to allow the airport managing body to vary the quality and scope of particular airport services, terminals or parts of terminals, with the aim of providing tailored services or a dedicated terminal or part of a terminal. The level of airport charges may be differentiated according to the quality and scope of such services and their costs or any other objective and transparent justification.

Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive by 15 March 2011. [1]

2. The Role of Airport Charges in the Slovak Republic

The concept of privatization of airports is very closely linked to airport charges. Privatization is defined as the transfer of more than 50 percent of the ownership of a business from the public sector to the private sector. Privatization came to be seen like method of creating a private sector in economies where all enterprises had traditionally been in the hands of the state. Airports have traditionally been owned by states, national or local governments. Situation changed, when BAA plc. started with the privatization of the three airports in the London area (Heathrow, Gatwick, and Stansted) and four other airports in the UK in 1987.

Now is the era of full private ownership of airports, which is more effective. This put pressure on airports to get more efficient airport services. Airports have always been recognized as an essential component of the national aviation system, they were only considered as being a platform providing the necessary services to airlines operations, without having a specific role in the air transport market development. As a consequence, commercial activities were not much developed by airports. This explains why airports property was always publicly managed while commercial activities, when needed, were outsourced to private companies. [13]

Many other European airports have already been or are in the process of being privatized. The majority stakes of Vienna International Airport, Copenhagen Kastrup International Airport, Rome Leonardo Da Vinci Airport and 49% of Schiphol Airport have been sold to private owners. Around the world were privatized many airports as a large number of major Australian airports – Auckland International Airport and Wellington International Airport in New Zealand. Argentina, Mexico and many Asian countries and countries in South Africa, are also in the process of privatizing their airports. In The the Slovak Republic was preparing the privatisation process for Airport Bratislava, but after short time was cancelled. Airport Košice are since the 25-th of October 2006 in the hand of private owner – KSC Holding (Airport Vienna and Raiffeissen ZentralBank Gruppe) with 66% share of company and 34% share of company are still in state ownership represented by The Ministry of Transport, Posts and Telecommunications of the Slovak Republic.

The basic idea of business is an effort at achieving a profit. There has to be balance and suitability between the expenses and revenues. The fundamental cost items are staff costs, maintenance expenses, depreciation, amortization and impairment (operating expenses). The fundamental revenue items are airport taxes, parking charges, security charges, landing charges, handling revenue, financial revenue and other commercial revenues. The dual till regulation of airport charges means primary the regulation of landing charges, parking charges, passenger service charges and secondary noise and security charges. In the single till regulation are implicit revenues from commercial activities, too**.**

But the most important for the airports is the special situation because of their localization. Many experts on airports economic declare that airports are nature monopolies. But is it true? The true is that, they are local or geographic monopolies (natural monopolies). This position is very important. Competition from other airports is at best limited if not non-existent. Market power enables airports to raise their prices, and to extract rents from the customers. Therefore the rationale for regulating airports has seldom been questioned. Regulation aims at controlling costs and prices, and quality of services. The aeronautical services include runway facilities for aircraft landing and take off, terminal buildings for passenger traffic, technical services to the aircraft such as fuelling and maintenance, and navigational services, etc. [14] The non-aeronautical services are concession revenues (rents – from banks, bars, parking cars...). For the past two decades, concession revenue has grown faster than aviation revenue; as a consequence, concession operations are now significant sources of revenues and profits for many major airports in the world. The same situation is at the Airport Košice, but Bratislava Airport has only small parts of the revenues from commercial activities.

The airport charges of the airports in the Slovak Republic are published in Aeronautical Information Publication (AIP SR). The comparison of Slovak unregulated airport charges and British regulated airport charges is very interesting. In the Slovak Republic airport charges are divided into traffic within the Slovak Republic and international traffic. This separation between domestic traffic and international traffic is in contradiction with the European law – Article 72 and 81 (1)d of EC Treaty, however European Court of Justice in Case C-92/01 has declared the specific situation in which such a separation is permissible, i.e. the costs of domestic flights must be legitimately lower than the costs of international flights.

Table 1. Rates per each tonne (even initiated) of the maximum take-off mass (MTOM) of the aircraft-traffic within the Slovak Republic (domestic traffic)

Traffic within the Slovak Republic	
Airports	**euro/tonne**
Košice	10,963
Bratislava	5,145
Nitra	0,332
Piešťany	4,647
Pievidza	0,332
Poprad-Tatry	4,647
Sliač	4,647
Žilina	4,647
Trenčín	1,327

Source [2]

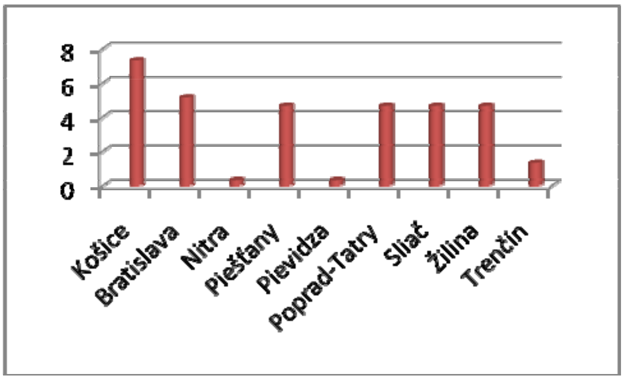

Figure 1. Rates per each tonne (even initiated) of the maximum take-off mass (MTOM) of the aircraft- traffic within the Slovak Republic (domestic traffic)

Table 2. Rates per each tonne (even initiated) of the maximum take-off mass (MTOM) of the aircraft- International traffic

International traffic	
Airports	**euro/tonne**
Košice	14, 107
Bratislava	13,111*
Piešťany	12,447
Poprad-Tatry	12,447
Sliač	12,447
Žilina	12,447

Sources [2]

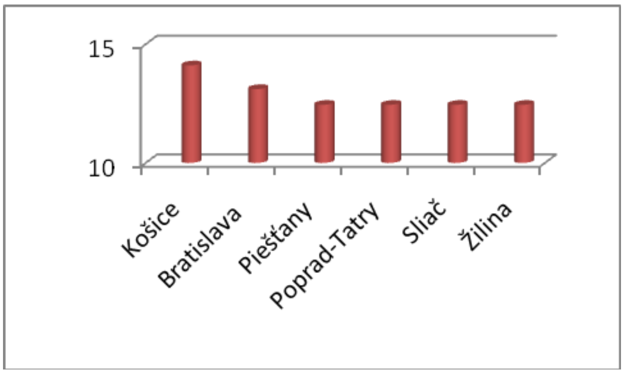

Figure 2. Rates per each tonne (even initiated) of the maximum take-off mass (MTOM) of the aircraft- International traffic

* On the Bratislava Airport are three categories of maximal take-off mass (MTOM):

- ✓ first 150 t, included aircraft landing charges are 13,111 euros per tonne
- ✓ each next 151 to 250 t – aircraft landing charges are 9, 294 euros per tonne
- ✓ each next 251 t – aircraft landing charges are 6,638 euros per tonne.

3. Representative Regulated British Airports and Airport Charges

The airport charges at regulated British airports are divided into peak and off peak traffic and into four categories of maximal take-off mass (MTOM).

Table 3. Aircraft landing charges at regulated British airports – Domestic traffic/ International traffic

Aircraft landing charges at regulated British airports						
	London Heathrow		London Gatwick		London Stansted	
Aircraft categories (t=tonnes)	Peak Euros per aircraft	Off-peak Euros per aircraft	Peak Euros per aircraft	Off-peak Euros per aircraft	Peak Euros per aircraft	Off-peak Euros per aircraft
MTOM < 16 t	686,760	291,000	429,814	128,040	110,580	98,940
16>MTOMW < 50 t	686,760	291,000	429,814	128,040	165,288	122,220
50>MTOM < 250 t	686,760	494,700	429,814	145,500	268,884	152,484
MTOM> 250 t	686,760	494,700	429,814	145,500	465,600	465,600

Source [3]

Table 4. Average rates per each tonne (even initiated) of the maximum take-off mass (MTOM) of the aircraft at regulated British airports– Domestic traffic/ International traffic

London Heathrow	London Gatwick	London Stansted
11,1661 euro/tonnes	6,2802 euro/tonnes	2,946775 euro/tonnes

Source: authors

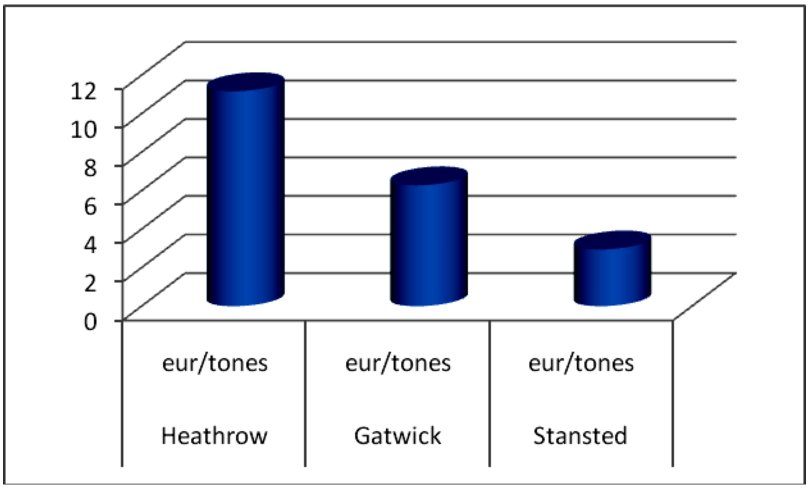

Figure 3. Average rates per each tonne (even initiated) of the maximum take-off mass (MTOM) of the aircraft at regulated British airports – Domestic traffic/ International traffic

4. Comparison of Airport Charges at British and Slovak Airports

The large differences between Slovak and British aircraft landing charges are shown in Tables 5. The most expensive airport in Great Britain – London Heathrow is cheaper than the cheapest Slovak international airport Poprad-Tatry.

Table 5. Comparison of aircraft landing charges at Slovak and British airports

Heathrow	Gatwick	Stansted	Bratislava	Košice	Poprad-Tatry
11,1661 euro/tonnes	6,2802 euro/tonnes	2,946775 euro/tonnes	13,111 euro/tonnes	14,107 euro/tonnes	12,447 euro/tonnes

Source: authors

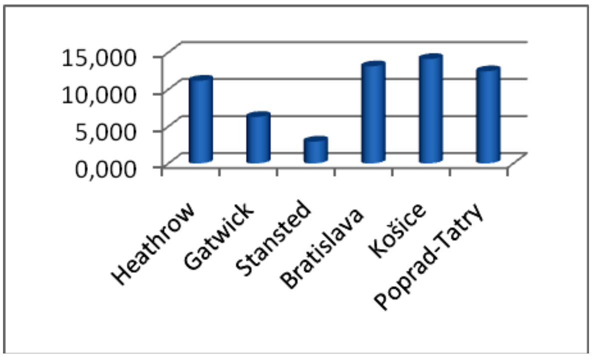

Figure 4. Comparison of aircraft landing charges at Slovak and British airports

Table 6. Comparison of parking charges at Slovak and British airports

Comparison of parking charges on Slovak and British airports (Euros per MTOM)						
Airports	**London Heathrow**	**London Gatwick**	**London Stansted**	**Bratislava**	**Košice**	**Poprad-Tatry**
Parking charges (Euros/tonnes MTOM)	0,536	0,348	0,844	0,298	1,327	0,298
Fixed parking charges	8,241	5,61	3,422	0	0	0

Source: authors

Slovak airports do not have fixed parking charges. Parking charges per tonnes of MTOM are in average higher than British. The most expensive is Košice airport, but airports in Great Britain have two components of parking charges and the total parking charges are higher at British airports.

The level of airport taxes is described in Table 7. The most expensive is London Heathrow and the second one is Košice airport.

Table 7. Comparison of airport taxes at Slovak and British airports

Comparison of airport taxes at Slovak and British airports (Euros/pax)						
Airport	**London Heathrow**	**London Gatwick**	**London Stansted**	**Bratislava**	**Košice**	**Poprad-Tatry**
Domestic traffic	15,633	8,555	7,112	6,306	10,455	4,315
International traffic	26,737	13,048	10,790	16,265	16,265	14,339

Source: authors

Following this analysis we can identify some important parameters for economic regulation of airports. The tables show that economic regulation is beneficial, because it results in airport charges that are on average lower, but it is not the only aspect. For implementation of economic regulation the capacity of the regulated airport is important parameters. Airports which can not increase their capacity have to be regulated since they have a specific market position and the regulator must eliminate their monopolistic position and the associated disproportionate profits.

5. Economic Regulation of Airports in the Slovak Republic

The situation in Slovakia and at the Slovak airports demonstrates some differences from those in other Member states. Airports are in a special and problematic position. After research of theoretical models commonly used in Europe, Latin America and Australia a matrix or portfolio of various possibilities of alternative approaches to the application of economic regulation of the Slovak airports has been compiled and is evaluated on Figure 5.

Mechanism of Economic regulation of airports		Approaches of ERoA		
		Single till	Dual till	Hybrid
Hard regulation	RoR			
	Price cap	✓	✓	
	Hybrid RoR a Price cap			
	Default regulation			
Soft regulation	Light handed		✓	

Figure 5. Portfolio of various possibilities of alternative approaches to the application of economic regulation at Slovak airports

Out of a total of 8 international SK airports (Bratislava, Košice, Poprad-Tatry, Žilina, Sliač, Piešťany, Nitra and Prievidza), only two, Bratislava and Košice, could be relevant for economic regulation of airport.

Košice airport is a small regional airport, but has great local position. This airport can be defined as a geographic monopoly, i.e. a natural monopoly. However it is too small for regulation as the Directive applies to airports that are above a minimum size (5 mil. pax), because management and the funding of small airports not calling for the application of the Community framework.

Regarding Bratislava Airport, the Directive requires regulation of this airport as the biggest airport in Slovakia. However, experts on economic regulation believe that it is unnecessary, because this airport is not a local monopoly and is located close to the Vienna Airport (only 60 km by highway). So what we can do? We have to respect principles of EU and the Directive and regulate airport charges there, but it can be the end. Bratislava airport aspires to compete with Vienna Airport, but currently does not have a sufficiently large passenger flow. The situation on the air transport market during the current economic crisis complicated and some airlines have stopped operating from and to Bratislava airport.

6. Simulation at Bratislava Airport after Application of Created Hard Regulation Formula of Economic Regulation of Airport Charges

Simulation of situation at the Bratislava Airport after the introduction of the hard regulation formula – price cap single till – is one of the opportunities how to analyse the situation and choose the best method of regulation. On the other hand, the research illustrates the possibilities of economic regulation, which of the regulation mechanism is the best.

Price cap single till mechanism was considered the most appropriate for Airport Bratislava. The regulation formula is based on the research of the authors. Simulation is set for the five years period from 2010 till 2014. Data are from Airport Bratislava. [4]

The fundamental parameters of regulation formula are planned revenue, real revenue, planned passengers, real passengers, quality of service, CPI, average interest, trigger and the investments towards the new Terminal 2 at Bratislava airport.

The maximum permitted revenue per passenger for the regulatory period 2010 (P_{2010}):

$$P_{2010} = [P_{2009} + T2_{2010}] * QS_{2010},$$

where $T2_{2010}$ = X*(number of days, w hen Terminal T2 is opened in the year 2010)/365
X is set on the investments to the new Terminal 2
QS_{2010} = represents a Quality of Service adjustment that takes a value between 0 and 1 depending on Quality of Services, which are provide by Airport Bratislava.

$$QS_{2010} = 1 - \sum_{x=1}^{n} QS_x$$

- ✈ this coefficient QS_{2010} has more monitor parameters of quality n.

The rules established for QS_{2010}:

- number of days in 2010 when passengers in a terminal that is open have to queue for more than thirty minutes to pass through passenger security, subject to this sum never exceeding (QS1)
- number of days in 2010 when access to the outbound element of the baggage handling system is denied to an airline or airlines for more than thirty consecutive minutes due to a single event system failure (QS2)
- number of quarters in 2010 when the incoming element of the baggage handling system is available for less than 99% of operational hours (QS3)
- number of quarters that Bratislava airport breaks the rule of ACI 'ease of way-finding through airport'(QS4)
- number of quarters that Bratislava airport breaks the rule of ACI 'flight information screens' (QS5)
- number of quarters that Bratislava airport breaks the rule of ACI 'cleanliness of airport terminal'(QS6)
- number of quarters that Bratislava airport breaks the rule of ACI 'cleanliness of washrooms' (QS7)
- number of quarters that Bratislava airport breaks the rule of ACI 'comfort of waiting/gate (QS8)
- number of quarters that Bratislava airport breaks the rule of ACI 'courtesy/helpfulness of airport staff (excluding check-in & security)' (QS9)
- number of quarters that Bratislava airport breaks the rule of ACI 'courtesy/helpfulness of security staff'(QS10)
- number of quarters that Bratislava airport breaks the rule of ACI 'all passengers' overall satisfaction with the airport' (QS11)
- number of quarters that Bratislava airport breaks the rule of ACI 'communications/ telecommunications/e-facilities' (QS12)

The maximum permitted revenue per passenger for the regulatory period 2011 (P_{2011}):

$$P_{2011} = [(P_{2010} + T2_{2011} + \mathrm{Trigger}_{2011}) * (1 + CPI_{2010}) + k_{2009} + w_{2009}] * QS_{2011}$$

$T2_{2011}$ = X*(number of days, hen Terminal T2 is opened in the year 2011)/365

Trigger2011 = $\sum$ sum of special coefficients

- sum of special coefficients, which depend on the special situations, conditions and changes in the legislation

where:

- this data depend on the expanses of passenger and investments to the runways (the runway trigger)
- a week in 2010 when demand for aircraft stands was greater than xy (the apron development trigger)
- legislation requires an upgrade of the Bratislava airport baggage security equipment prior to the end of 2011

***CPI*₂₀₁₀** is the percentage change (whether of a positive or negative value) in the consumer price index between those published in October 2009 and October 2010 by National Bank of Slovakia[1]

***k*₂₀₀₉** is a correction per passenger to be made in the regulatory year 2011 on account in the regulatory year 2009. It is derived from the following formula:

[1] http://forecasts.org/cpi.htm zo dňa 17.5.2010, http://portal.statistics.sk/showdoc.do?docid=15694 _17.5.2010

$$k_{2009} = \left(Y_{2009f} - Y^{*}_{2009}\right) * \left(\frac{Pax_{2009}}{Pax_{2009f}}\right) * \left(1 + \frac{I_{2009}}{100}\right) * \left(1 + \frac{I_{2010}}{100}\right).$$

$\boldsymbol{Y_{2009\,f}}$ is the forecast average revenue per passenger collected from airport charges levied at Bratislava airport in 2009

$\boldsymbol{Y^{*}_{2009}}$ is the actual average revenue per passenger collected from airport charges levied at Bratislava airport in 2009

$\boldsymbol{Pax_{2009\,f}}$ is the forecast number of passengers using Bratislava airport during 2009

$\boldsymbol{Pax_{\,2009}}$ is the actual number of passengers using Bratislava airport during 2009

$\boldsymbol{I_{2009}}$ is the average year interest rate between 1 October 2008 and 1 October 2009[2]

$\boldsymbol{I_{2010}}$ is the average year interest rate between 1 October 2009 and 1 October 2010, which is set in the forecast for the next period[3]

$\boldsymbol{W_{2009}}$ is a correction per passenger to be made in the regulatory year 2011 on account of any difference for the year 2009 – actual costs and expenses and budgeted costs and expenses that are recoverable through airport charges levied at Bratislava airport. It is derived from the following formula:

$$\mathrm{w}_{2009} = \left[\mathrm{WA}_{2009} - \left(\mathrm{WF}_{2009} * (1 + \mathrm{CPI}_{2009})\right)\right] * \left(\frac{1}{\mathrm{Pax}_{2009\mathrm{f}}}\right) * \left(1 + \frac{\mathrm{I}_{2009}}{100}\right) * \left(1 + \frac{\mathrm{I}_{2010}}{100}\right),$$

$\boldsymbol{WA_{2009}}$ – real costs, which are paid from airport charges

$\boldsymbol{WF_{2009}}$ – forecast costs, which are paid from airport charges

This correction is very important, since the correction renders the formula more realistic, however at this moment its value is set at 0 because Bratislava airport could not estimate this value and coefficient. The maximum permitted revenue per passenger for the regulatory period 2012, 2013 and 2014 can be evaluated and set on the same basis and formulas with actual data and values.

Table 8. Simulation parameter values at Bratislava airport after application of hard regulation formula – price cap single till

Parameter	**ROK**						
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Forecast revenue per pax [Yn]	14,88 €	12,94 €	13,38 €	13,89 €	14,28 €	15,04 €	15,32 €
Real cost paid from airport charges [WAn]	–						
Forecast cost paid from airport charges [WFn]	–						
Correction coefficient per pax [wn]	–	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	
		0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	
Correction coefficient [kn]	–	-4,65 €	-4,49 €	-2,45 €	-0,91 €	-0,30 €	
		-11,01 €	-13,48 €	4,35 €	24,03 €	13,99 €	
Trigger n	–	0	0	0	0	0	0

[2] www.nbs.sk 15.5.2010
[3] http://forecasts.org/5yrT.htm 18.5.2010

Continuation of Tabl.8

Parameter	ROK						
	2008	2009	2010	2011	2012	2013	2014
Quality coefficient– Quality of Services [QSn]	–	–	0,965	0,945	0,935	0,935	0,935
Costs per pax in T2 [Tn]	–	–	1,80 €	2,13 €	2,41 €	2,29 €	0,96 €
Revenues per pax [Pn]	16,02 €	19,94 €	20,98 €	17,99 €	15,73 €	15,49 €	15,53 €
			20,98 €	11,44 €	0,34 €	6,53 €	29,47 €
Revenues per pax [Pn] [kn=0 a wn=0]	16,02 €	19,94 €	20,98 €	21,84 €	22,67 €	23,34 €	22,72 €
Total airport revenue /pax forecast	14,88 €	12,94 €	13,38 €	13,89 €	14,28 €	15,04 €	15,32 €
Total airport revenue /real pax	16,02 €	19,94 €	23,28 €	24,18 €	24,14 €	24,23 €	23,55 €

Source: authors

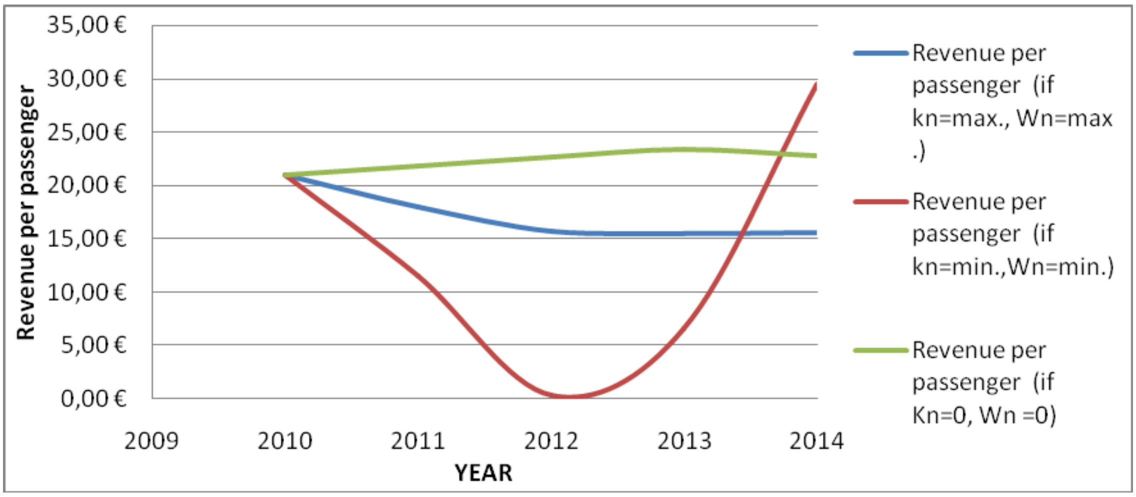

Figure 6. Hypothetical variants of maximum permitted revenue per passenger for the regulatory period based on the authors' regulation formula

Conclusions

Based on the fundamental theoretical knowledge and the special practical analyses and research in the Slovak Republic especially the Bratislava airport, the authors created a hard regulation formula, which could be introduced at the Bratislava airport after the 11th of March, 2011. The regulation formula has many positive and negative aspects. The main negative aspect is the problem with the quality of data that can be provided by the Bratislava airport. We do not have enough data for a correction coefficient, which can be used to adjust the formula and make the maximum permitted revenue per passenger for the regulatory period more realistic.

Research indicates that the model of „hard regulation“ in the Slovak Republic – revenue price cap single till – is not suitable for this kind of airports, because it is overly complicated and the Slovak Republic does not have enough experiences with economic regulation of airports to carry it out. Bratislava airport wants to increase the passenger flow and the number of airlines with base in Bratislava, so the goal is to have airport charges at the lowest possible level. After analysis and selection of relevant parameters we hope to demonstrate in further research that the best way for Bratislava airport is the light handed regulation (monitoring of prices).

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EFFICIENCY OF ONBOARD COMPUTER SYSTEMS FOR SPACE VEHICLES AND STATIONS

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The technique of complex efficiency estimation for in space vehicles and stations used onboard computer systems is considered. A tooling for such estimation is offered: efficiency criteria and etalon vectors of operations rate, considering the specificity of onboard computer systems functioning and structure.

Keywords: efficiency, criterion of efficiency, control tasks and algorithms, instruction set, performance, average speed, etalon operations frequency vector

1. Introduction

Modern onboard computer systems (OCS), embedded in space vehicles (stations), and controlling their work, refer to the class of complex systems. They consist of a great number of on VLSI crystals allocated components, and have a range of factors, characterizing particular system's properties. A task arises of imposing a measure for estimation of OCS conformance degree for implementation of on it placed functions — efficiency measure.

Efficiency defines the degree of OCS conformity to its purpose. It is measured either by an amount of expenses for getting of certain result, or by the result, got at certain expenses. Criterion of efficiency allows comparing efficiencies of several OCS, as well as making a decision on the use of a particular system.

C*riterion of efficiency* is a rule, serving for comparative estimation of quality for different OCS releases. The criterion of efficiency can be named the rule of preference of the compared choices.

Criterions of efficiency are built on the basis of particular efficiency factors (quality indexes). The way of connections between particular indexes defines the kind of efficiency criterion.

2. Derivation of Basic Indexes for OCS Efficiency Estimation

For estimation of efficiency will specify the OCS indexes by two vectors:

- vector of technical indexes *TP*;
- vector of algorithmic indexes *AP*.

Vector of technical indexes looks like:

$$TP = \{C, M, W, P, R_\mathrm{i}, R_\mathrm{d}, E_\mathrm{ram}, E_\mathrm{rom}\},$$

where $TP_1 = C$ — complexity [amount of conditional elements — cnd. el.],
$TP_2 = M$ — mass [kg],
$TP_3 = W$ — volume [l],
$TP_4 = P$ — power consumption [W],
$TP_5 = R_\mathrm{i}$ — instruction width [bit],
$TP_6 = R_\mathrm{d}$ — operand width [bit],
$TP_7 = E_\mathrm{ram}$ — RAM capacity [Kwords],
$TP_8 = E_\mathrm{rom}$ — ROM capacity [Kwords].

Vector of algorithmic indexes will present as follows:

$$AP = \{V_\mathrm{n}, V_\mathrm{av}^\mathrm{fly}, \mu, P^\mathrm{fly}, \delta_\mathrm{R}, \delta_\mathrm{E}\},$$

where V_{n} — OCS rated speed,

$V_{\mathrm{av}}^{\mathrm{fly}}$ — OCS average speed at solution of space vehicle (SV) flight control tasks,

μ — operation set efficiency coefficient,

P^{fly} — OCS performance at solution of SV flight control tasks,

δ_{R} — OCS operand length widening index, ($\delta_{\mathrm{R}} = 1$ if extension of operand length is possible, otherwise $\delta_{\mathrm{R}} = 0$),

δ_{E} — OCS memory capacity enlargement index ($\delta_{\mathrm{E}} = 1$ if extension of memory capacity is possible).

The rated speed depends only on OCS hardware possibilities at implementation of a standard operation. As a standard a short operation of addition is usually chosen. The rated speed, expressed through the time of addition τ_{add} will be defined from expression

$$V_{\mathrm{n}} = \frac{1}{\tau_{\mathrm{add}}} \left[\frac{\mathrm{op}}{\mathrm{s}}\right].$$

Average speed on flight control tasks is a generalised index and can be used in the integrated criterion of efficiency, since it depends on a great number of OCS parameters as well as on a quantity of parameters of algorithms, used for SV control tasks solving.

The formula for calculation of $V_{\mathrm{av}}^{\mathrm{fly}}$ can be deduced from following considerations.

Let in the SV flight control process m particular control tasks are solved, at that solution time for j^{th} particular task is T_j, solution cyclicity — T_{j*}, number of operations at executing j^{th} task — N_j.

For a set of given particular control tasks will find the maximal value of solving periodicity

$$T_{\max *} = \max_j (T_{1*}, ..., T_{j*}, ..., T_{m*}) .$$

In the course of time $T_{\max *}$ the j^{th} particular control task will be solved α_j times:

$$\alpha_j = \frac{T_{\max *}}{T_{j*}} . (j = 1, 2, \ldots, m). \tag{1.1}$$

Using (1.1), the expression for average speed at SV flight control can be written down as

$$V_{\mathrm{av}}^{\mathrm{fly}} = \frac{\sum_{j=1}^{m} \alpha_j N_j}{\sum_{j=1}^{m} \alpha_j T_j} . \tag{1.2}$$

Having designated in (1.2)

$$\beta_{j*} = \frac{\alpha_j}{\sum_{j=1}^{m} \alpha_j N_j}, \tag{1.3}$$

will get

$$V_{\mathrm{av}}^{\mathrm{fly}} = \frac{1}{\sum_{j=1}^{m} \beta_{j*} T_j} , \tag{1.4}$$

where β_{j*} — frequency of j^{th} particular task solving in the SV flight control process.

In turn, average time for solving of j^{th} particular task of control is defined from expression

$$T_j = N_j \tau_{avj} = N_j \times \sum_{j=1}^{l} q_{ji}\tau_i, , \tag{1.5}$$

where τ_{avj} — average duration of OCS operations on a j^{th} task,
l — number of OCS operation types on a j^{th} task,
q_{ji} — frequency of i^{th} type operations in a j^{th} task,
τ_i — time of execution of i^{th} type operation in the j^{th} control task.

Putting (1.5) in (1.4), will write down a formula for the calculation of average processing speed at flight control as

$$V_{\text{av}}^{\text{fly}} = \frac{1}{\sum_{j=1}^{m}\sum_{i=1}^{l} \beta_{j*} N_j q_{ji} \tau_i}. \tag{1.6}$$

Having imposed a designation

$$\beta_j = \beta_{j*} \times N_j = \frac{\alpha_j}{\sum_{j=1}^{m} \alpha_j N_j} \times N_j, \tag{1.7}$$

will get final expression for average OCS processing speed at SV flight control

$$V_{\text{av}}^{\text{fly}} = \frac{1}{\sum_{j=1}^{m}\sum_{i=1}^{l} \beta_j q_{ji} \tau_i} \left[\frac{\text{op}}{\text{s}}\right], \tag{1.8}$$

where β_j defines how frequently the operations of j^{th} particular task appears in the full SV flight control task.

For calculations on a formula (1.8) it is necessary to know OCS parameters, presented by a vector $\{\tau_1, \tau_2, ..., \tau_l\}$, parameters of each j^{th} particular control task — vector $\{q_{j1}, q_{j2}, ..., q_{jl}\}$, and parameters of a full flight control task —vector $\{\beta_1, \beta_2, ..., \beta_m\}$.

The most labour intensive is determination of great number of vectors $\{q_{ji}, | j = 1, …, m, i = 1, …, l\}$, because the statistical estimation of all control particular tasks programs realizing is here required.

Statistical estimation of real programs for universal computers is replaced by using of the standard frequency vector, defined on a mix of scientific and technical tasks.

However parameters of a typical mix of scientific and technical tasks greatly differ from the parameters of SV flight control tasks, therefore the standard frequency vector cannot be used at calculation of $V_{\text{av}}^{\text{fly}}$.

From here necessity of definition of great number of etalon frequency vectors for flight control tasks follows.

Knowing V_{n} and $V_{\text{av}}^{\text{fly}}$, it is easy to calculate the efficiency of OCS operation set

$$\mu = V_{\text{n}} / V_{\text{av}}^{\text{fly}}. \tag{1.9}$$

Factor μ value characterizes the degree of conformity of OCS operation set to the flight control tasks solution algorithms, and shows, in how many times decreases the OCS processing speed at execution of real flight programs, as compared to V_n.

To have a chance to analyse the efficiency of separate OCS operations realization, will introduce a criterion for estimation of separate operations influence on an average duration of flight control particular tasks operations.

As a criterion it is convenient to use the coefficient of relative increments to average duration of operation τ_{av} due to operations of i^{th} type

$$\eta_{ji} = q_{ji}\left(\frac{\tau_i}{\tau_{\text{add}}} - 1\right) \to min. \tag{1.10}$$

With the use of (1.10) the expression for average duration of j^{th} particular control task operations will become

$$\tau_{avj} = (1 + \sum_{j=1}^{l} \eta_{ji})\tau_{\text{add}}. \tag{1.11}$$

From (1.11) follows that the η_{ji} coefficient module characterizes the value of average duration change in relation to base operation duration, over appearance in the program of i^{th} operation with frequency q_{ji}. The sign of the η_{ji} coefficient reflects the direction of this change — towards τ_{avj} increase or decrease relatively the τ_{add}.

OCS performance at solving of flight control tasks is defined from the relation

$$P^{\text{fly}} = \frac{V_{\text{av}}^{\text{fly}}}{\sum_{j=1}^{m} \alpha_j N_j}. \tag{1.12}$$

Passing to "tasks/s" dimension, and substituting in (1.12) the (1.6) expression with an account of (1.3), will get the final formula for calculation of the OCS performance

$$P^{\text{fly}} = \frac{1}{\sum_{j=1}^{m}\sum_{i=1}^{l} \alpha_j N_j q_{ij} \tau_i} \left[\frac{\text{tasks}}{\text{s}}\right]. \tag{1.13}$$

3. Synthesis of the Generalised Criteria of OCS Efficiency

An integrated efficiency assessment and OCS choice (synthesis) is a multicriterion task, whose solution quality x requires introduction of great number of particular criteria:

$$\overrightarrow{\mathrm{K}}(x) = \{k_1(x), k_2(x), ..., k_n(x)\}. \tag{1.14}$$

Particular criteria $k_s(x)$ are built on the basis of *TP* and *AP* vectors.

It is known that at multicriterion approach it is not enough to set great number of particular criteria and their coupling with the OCS parameters. It is necessary also to choose the pattern of compromises, on which basis the rules of solution search are formulated.

Two groups of patterns of compromises and, accordingly, two approaches to the task solution can be distinguished:

- reducing of vector criterion to scalar;
- lexicographic optimisation.

In the reduction methods a vectorial task comes to the scalar task

$$\mathrm{K}(x) \to \underset{x \in \mathrm{X}}{extr},$$

where X is a set of feasible solutions,
$\mathrm{K}(x)$ — scalar criterion, being some function of the values of vectorial criterion (1.14) components:

$$\mathrm{K}(x) = f(k_1(x), k_2(x), ..., k_n(x)).$$

The main feature of this approach is in necessity of convolution function f construction. Basic difficulties here arise during accounting of priorities of particular criteria, which is carried out by defining of a vector of criteria importance coefficients

$\Lambda = \{\lambda_1, \lambda_2, ..., \lambda_n\}$,

where λ_i is a coefficient of a particular criterion importance $k_i(x)$.

At the heart of lexicographic optimisation lies the idea of absolute putting in order of particular criteria accordingly mutual importance and consecutive usage of these criteria for receiving of optimum decision. Essentially important difference of lexicographic optimisation from reduction methods is sufficiency of qualitative, instead of quantitative regulating. Possibility of qualitative regulating of particular criteria largely simplifies task solution.

For the estimation of OCS efficiency a special case of lexicographic optimisation is of a particular interest — optimisation on a scalar criterion at presence of restrictions:

$$k_1(x) \to \underset{x \in X}{extr};$$

$$k_i(x) \geq k_i^{req}, i = 2, ..., n,$$

$$k_j(x) \leq k_j^{req}, j = n+1, ..., m,$$

where $k_1(x)$ is the most important particular criterion.

Basic advantage of this method is that a task can be solved by using of well studied methods of mathematical programming. Besides, at such statement on the $\underset{x \in X}{k_i(x)}$ value area the requirements of continuity and convexity are not imposed.

The generalised criterion of OCS efficiency should take into account both technical, and algorithmic OCS characteristics. Therefore at synthesis of the first particular criterion it is convenient to take for a basis the criterion of the effective speed price, offered by S .A. Mayorov and G. I. Novikov, and based on the V.M. Glushkov's ideas:

$$K = \frac{S}{V_{\text{av}}} \to min, \tag{1.15}$$

where S — cost, V_{av} — average computer processing speed.

Here the average speed is defined under the formula

$$V_{\text{av}} = \frac{1}{\sum_{i=1}^{l} q_i \tau_i} \left[\frac{\text{op}}{\text{s}}\right]. \tag{1.16}$$

Vector $\{\tau_1, \tau_2, ..., \tau_l\}$ in expression (1.16) characterizes the computer instruction set, and $\{q_1, q_2, ..., q_l\}$ vector, called operations frequency vector, characterizes an algorithm.

It is obvious that for "tuning" to the OCS, V_{av} index in (1.15) must be replaced by $V_{\text{av}}^{\text{fly}}$:

$$K = \frac{S}{V_{\text{av}}^{\text{fly}}} \to min. \tag{1.17}$$

The formula of criterion (1.17) characterizes monetary expenditures on unit of speed at SV flight control process.

With reference to the purposes of OCS estimation will improve criterion (1.17) as follows. First, instead of the monetary will estimate hardware OCS expenses, using complexity factor C [cnd. el.]. Secondly, in place of average speed at flight control will introduce an index of informational speed at flight control

$$V_{\text{inf}}^{\text{fly}} = V_{\text{av}}^{\text{fly}} \times \sum_{j=1}^{m} \sum_{i=1}^{l} \beta_j q_{ji} R_i \left[\frac{\text{Kbit}}{\text{s}}\right], \tag{1.18}$$

where R_i — operand width at execution of i^{th} operation, the $V_{\text{av}}^{\text{fly}}$ factor, and β_j, q_{ij} parameters are calculated on formulas (1.7), (1.8). The use of $V_{\text{inf}}^{\text{fly}}$ index allows OCS comparing with different operand length (including with varying length).

Taking into account the aforesaid, will get the criterion of informational speed price at flight control

$$K_{pis} = \frac{C}{V_{\text{av}}^{\text{fly}} \times \sum_{j=1}^{m}\sum_{i=1}^{l} \beta_j q_{ji} R_i} \left[\frac{\text{cnd. el.} \bullet \text{s}}{\text{Kbit}}\right] \to min$$

$$TP_k \le TP_k^{req}, k = 1,2,3,4. \tag{1.19}$$

$$TP_k \ge TP_k^{req}, k = 5,6,7,8.$$

where TP_k — k^{th} technical index of the OCS (a component of TP vector), TP_k^{req} — desired value of OCS k^{th} technical index.

The formula of criterion (1.19) takes into account basic features of computational process in OCS:

- real time mode
- machine time sharing between particular control algorithms
- modularity of particular algorithms
- cyclicity of control algorithms execution
- dynamically changeable digit capacity of calculations
- existence of rigid resource constraint.

However the coincidence degree in the central processor and input-output devices work, as well as time, spent for transfer of the data from external memory in main memory, is thus ignored.

Noted factors can be taken into account in the criterion of the performance price at flight control

$$K_{pp} = \frac{C}{P^{\text{fly}}} \left[\frac{\text{cnd. el.} \bullet \text{s}}{\text{task}}\right] \to min,$$

$$TP_k \le TP_k^{req}, k = 1, 2, 3, 4, \tag{1.20}$$

$$TP_k \ge TP_k^{req}, k = 5, 6, 7, 8,$$

where OCS performance at implementation of full flight control algorithm is estimated on formula (1.13).

4. Etalon Frequency Vectors for Flight Control Tasks

The analysis was carried out in a context of Space Shuttle SV flight control tasks. As the OCS of this SV has an instruction set compatible with IBM 370/390 family, the following ***hypothesis*** is accepted: instruction set of the etalon OCS is a subset of IBM 370 fixed-point instructions, base operands width — 16 bits (denoted R), the double word width — 32 bits (denoted $2R$).

Typical algorithms of flight control were programmed: navigation, guidance, stabilization. The compiler generated assembler code for chosen subset of instructions.

The results of flight control programs statistical treatment are of the form:

$$\tau_{av}^{nav} = 0,54\tau_{RX} + 0,36\tau_{RI} + 0,04\tau_{2R} + 0,04\tau_{Mul-2R} + 0,02\tau_{Sft11-2R},$$

where τ_{av}^{nav} — average duration of navigation operation,

τ_{RX} — duration of RX format addition type operation,

τ_{RI} — duration of RI format addition type operation,

τ_{2R} — duration of double width RX format addition type operation,

τ_{Mul-2R} — duration of double width RX format multiplication operation,

$\tau_{Sft11-2R}$ — duration of double width RX format operand shift operation on 11 digits.

Length of the navigation program N_{nav} = 1137, frequency of its operations appearance in a full control cycle $\beta_{nav} = 0,144$, cyclicity (number of inclusions) of navigation program in a full control cycle $\alpha_{nav} = 1$.

$$\tau_{av}^{gd} = 0,56\tau_{RX} + 0,35\tau_{RI} + 0,01\tau_{Mul} + 0,03\tau_{2R} + 0,03\tau_{Mul-2R} + 0,02\tau_{Sft4-2R},$$

where τ_{av}^{gd} — average duration of guidance operation,

τ_{Mul} — duration of *RX* format multiplication operation,

$\tau_{Sft4-2R}$ — duration of *RX* format double width operand shift operation on 4 digits.

Length of the guidance program N_{gd} = 3330, frequency of appearance of its operations in a full control cycle $\beta_{gd} = 0,421$, cyclicity (number of inclusions) of guidance program in a full control cycle $\alpha_{gd} = 1$.

$$\tau_{av}^{st} = 0,59\tau_{RX} + 0,28\tau_{RI} + 0,09\tau_{Sft6} + 0,04\tau_{Mul},$$

where τ_{av}^{st} — average duration of the stabilization operation,

τ_{Sft6} — duration of *RX* format single width operand shift operation on 6 digits.

Length of the stabilization program N_{st} = 1721, frequency of appearance of its operations in a full control cycle $\beta_{st} = 0,435$, cyclicity (number of inclusions) of stabilization program in a full control cycle $\alpha_{st} = 2$.

As in the etalon OCS only unary and double word width operands are processed, calculation of informational speed at flight control can be spent on the simplified formula:

$$V_{\inf}^{\text{fly}} = V_{\text{av}}^{\text{fly}} \times \sum_{j=1}^{3} \beta_j (q_{jR}R + q_{j2R}2R) \left[\frac{\text{Kbit}}{\text{s}}\right],$$

where q_{jR} — frequency of *R*-digit numbers processing operations,

q_{j2R} —frequency of 2*R*-digit numbers processing operations in a j^{th} particular control task.

For values of etalon frequency vectors the formula becomes:

$$V_{\inf}^{\text{fly}} = V_{\text{av}}^{\text{fly}} \times (0,95 \times R + \; 0,05 \times 2R) \left[\frac{\text{Kbit}}{\text{s}}\right].$$

Conclusions

One of actual problems in the development of space vehicles and stations, still, is the problem of effective choice and design of embedded computing facilities. Within the framework of this task solution, authors develop a methodology of integrated assessment of the OCS efficiency. A number of new criteria of efficiency is offered. These criteria enable to give an estimation of integral OCS efficiency, taking into account basic features of the computational process organization and OCS structure: real-time calculations, machine time sharing between the particular control tasks, modular nature of particular control tasks, cyclicity control tasks solving, dynamically changeable digit capacity of calculations, presence of rigid resource restrictions. For providing of new criteria practical use, a set of etalon operations frequency vectors, reflecting the specificity of the SV flight control tasks is synthesized.

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ESTIMATION OF MECHANICAL PROPERTIES OF THE ANISOTROPIC REINFORCED PLASTICS WITH APPLICATION OF THE METHOD OF ACOUSTIC EMISSION

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In this paper the results of the estimation of composite material's (the anisotropic reinforced plastics type) mechanical properties are presented.

The test loadings are applied on specimens with the longitudinal in one case and cross-section in another case of the reinforced fibres orientation in relation to the load direction. The specimens for static tension tests are presented as squared shape band with the moulding fixed plates on the both ends for mounting into the test rig's gapping jaws. The static test program consists of three - or six time specimen's loading to the level making 20% of the ultimate load; after that the loading goes non-stop to the collapse of specimen.

The possibility of the character and level of fibres and a matrix of composite specimen's damages estimation by acoustic emission signals' analysis is shown.

The test performed have shown that the acoustic emission method can be used in practice to carry out the probes of responsible avia/space devices designed of anisotropic reinforced plastics.

Keywords: composite materials, static tests, acoustic emission, ultimate loads

1. Introduction

Aero-Space branch produces the rigid requirements to working capacity and reliability of constructional materials. Recently more and more wide application is found by composite materials which possess variety of unique properties. That defines composites choice instead of metal alloys.

While metals are isotropic, composite materials are extremely isotropic. Composite pattern's strength along a direction of fibres may more than in 20 times to exceeds the strength of a matrix, the strength across fibres or the strength between layers. Thus, many kinds of destruction are possible; such as a tension, a compression, a shift in a sheet plane, an inter-laminar bonding shift, a flat tension and their combinations. But if the metal under the effect of the compression may only to be distorted rather than to be destruct, the polymer composite material may completely destroy, to divide or split the matrix parallel to the fibres.

Besides, composite materials are non-uniform. The pattern has various structures in various directions within a layer or on a thickness. In this connection if the classical approach is used to an estimation of the weariness, the creep and the growth of cracks, it is necessary to take into consideration various elements of a material (a fibre and a matrix), the orientation of fibres in relation to the loading and also their interaction. Even the static strength may be changed under the influence of the sequence of packing of layers, i.e. due to order in which identical layers have been kept within on a thickness.

Other prominent feature of compositions is their small deformations.

Inside the metal the local plastic deformation unloads the stress concentration and redistributes it in places of abrupt changes in geometry, defects and cut-outs. So the stress concentration factors K and Kf ratios of fatigue strength of metals have not been directly used for composite materials. Residual stresses, such as thermal, arising from the curing, become more significant than in metals, and may contribute to premature failure.

It should seriously look into the nature of the degradation of the matrix in composite materials. While the matrix is not exposed to the classical corrosion or the corrosion under stress, like metals, it may degrades from the aging, the exposure of the ultraviolet radiation, the humidity, lightning strikes, mechanic shocks and the environment erosion etc.. These phenomena should be taken into account when it comes to the pattern's long life time.

The degree of an admissible damage is various at compositions and metals and strongly depends on the design. For the reliability estimation it is necessary to understand, how damages influence the static and fatigue strength, the creep and the residual strength.

At last, unusual character of composite patterns and their joints causes of non-destructive testing complexity.

Composite materials such as fibrous composites keep the unique properties of the high strength and the low firmness, have good fatigue properties. So they may be applied in designs of any appointment.

Mechanics of composites studies their mechanical behaviour under the applying loads: the distribution of stresses and strains, by which the kinematics characteristics and the structural strength may be calculated. This investigation may be divided to macro-mechanics or micro-mechanics, depending on the scope of the observation. In the first case the material is considered to consist of homogeneous anisotropic layers, and the unknown quantities are the average stress, strain and tensile strength. This layered composite is characterized by two of Young modulus, two Poisson's ratios, shear modulus and the three values of the ultimate stress limits.

The micro-mechanical viewpoint is based on the fact that the behaviour of the composite material or the pattern is closely related to the level and distribution of internal stresses and load transferring from one component to another. In micro-mechanics these internal stresses, as well as the internal reaction and the interaction of individual pattern's parts, which are caused by applied forces, are studied. This data obtained are the basis for calculating and predicting the macroscopic behaviour of the material, determining the type of the destruction and establishing a criterion of strength limit.

Among the possible types of damage are distinguished the abruption of the matrix, the abruption at the interface between the fibre and matrix and the fibres abruption. These types of fracture are not independent, and may interact and stimulate each other. The beginning of the destruction is obviously determined by the internal stress state, which depends on the current applied load, the geometrical structure of the composite and the properties of its components. It may be that a stress distribution is very complex, and define it analytically is extremely difficult. Therefore experimental studies have a significant importance and even necessary sometimes.

The experimental methods what are applied to studying the mechanics of composites, engage a photo elasticity method, a stress measuring method, a Moire method, a holography and a method of an acoustic emission (AE). AE-method is applicable as a method of non-destructive inspection and is especially effective at the studying of micro-mechanics of the destruction.

When the unidirectional composite pattern is loaded across fibres, there the critical situation takes place. Thus pattern's ruggedness reaches a minimum and the criterion of the strength is defined by the stress and deformations level in a matrix. Concerning this case micro-mechanical and macro-mechanical probes mostly have the analytical character [1].

In some studies the average (macroscopic) mechanical properties have considered and give expressions for the modules in the transverse direction and the coefficients of thermal expansion of the composite. Some of these works are based on energy considerations, using variation principles, in others there is apply approximate empirical expressions.

The stresses in the matrix are important in the case where the load is applied in the direction along to fibres, as in this case the beginning of the destruction is depend on concentration of stresses and strains in the matrix. Due to the numerical method the growth of strain on the border of the matrix and fibres has been calculated [2]. Using numerical methods of the theory of elasticity the exact solution have been obtained [3]. Analytical methods were also developed to account for the influence of anisotropy an exact solution [4], viscoelastic properties, plasticity, and random packing of fibres.

Other important problem of micro-mechanics of composites is a studying of the loading transmission from a matrix to a fibre (or from a fibre to a matrix), when external force is applied in parallel fibres or at an angle to them. The large number of the experimental photo elastic probes is known devoted to the stress investigation inside a matrix, to distributions of stress at borders of the section of a matrix and a fibre, the stress concentration near the ends of fibres and their breaks, as well as kinds of the damage and its progress.

Most of these studies are qualitative in nature. Load transferring and especially the distribution of stresses and their concentration near the end of the fibre has been the subject of many studies that used two-dimensional model.

To date, the application of acoustic emission method to study dynamic phenomena has been very limited. This industry employs S. Huguet, N. Godin, R. Gaertner, L. Salmon, D. Villard [5].

In this article determinate the possibility of assessing the nature and level of damage to the fibres and matrix composite patterns due to analyses the parameters of AE in the course of the tests. It is assumed that the MAE can be used in practice during the test runs of important structures of aerospace vehicles, made of anisotropic reinforced plastics.

2. Methods of Testing

The methodology of the test trials were conducted in accordance with the requirements of ГОСТ 25.601-80 and ГОСТ 24778-81. Composite materials test samples with the longitudinal and transverse orientation of fibres relative to the direction of the applied load have been investigated. The test samples were rectangular plates with clamped ends lining for tensile testing (Fig. 1).

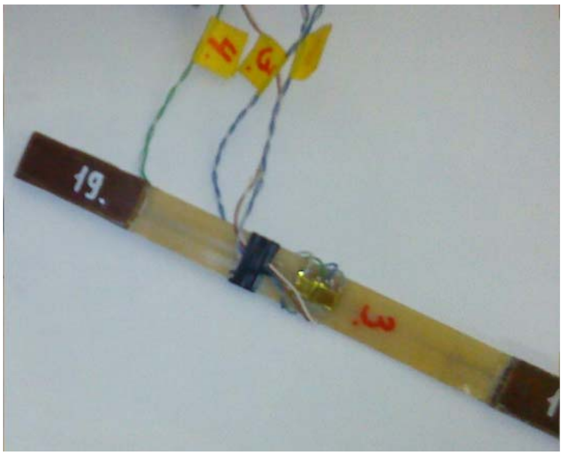


Figure 1. The test sample

The testing program included the as loading the sample only once to the destruction, and as samples incurring to three-and six-times loads of 10–30% of the fracture load and after that loading up till destruction.

Tests were performed on the thermo-stated branch, which is equipped with a hydraulic cylinder and a strain-gauge acquisition system. The loading process was monitored with the loading control system “Aviatest”. The bench was modified on base of a test machine WPM, (Germany), (Fig. 2).

Under the testing of samples the ambient temperature within t = + 22 ... 24 º C was maintained as a mandatory requirements.

The strain gauges were glued on each tested sample. The testing data were recorded with the acquisition system HBM MGCplus on tenso-metric module CANHEAD. This data contain information about the strength of loading, the displacement of the piston’s actuator, the strain of the sample.

These AE data were fixed with measuring system based on ГСП АРГУС-7 АФ-15 and the processor LCard L-783, under control of the program “Acoustic”; and device firms PAC POCKET AE-2.

a) b)

Figure 2. The test bench:
a) the test sample is attached to the bench; b) the thermostatic box stand

The Acoustic-Emission devices ГСП АРГУС-7 АФ-15 is a 2-channel recorder, which measures the total number of AE impulses and intensity of AE (bandwidth 20 kHz – 2.0 MHz).

The device of the Firm PAC POCKET AE-2 is a portable two-channel acoustic emission device, allowing fixing the parameters of acoustic emission. During the experiment one acoustic emission channel and a channel of a parametric input were activated. The following data were recorded: the time, the voltage on a parametric input, values of AE parameters (the intensity, the energy, the amplitude, the duration, the average frequency of AE signals).

The frequency response of the AE channel device "Pocket - AE2": from 1.0 kHz to 1.0 MHz + / – 1.5 dB.

As an AE sensor the piezo-converter П113 – (0,2-0,8) with a frequency range from 200 kHz to 800 kHz was chosen.

For the AE signals pre-amplification П113 (device АФ-15) with a constant 40 dB gain in frequency bands from 20 kHz to 2 MHz, and IL-LP-WS (PAC POCKET AE-2) with a constant 26 dB gain in frequency bands between 100 kHz up to 1 MHz were used.

AE sensors were attached to the sample with Cyanoacrylate-glue (Fig. 3).

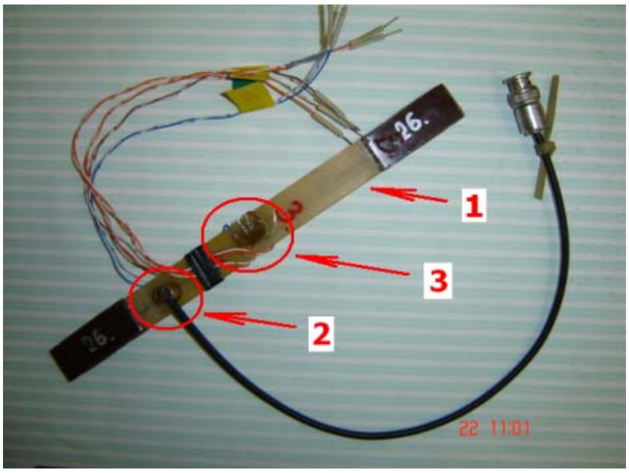


Figure 3. The attachment of the AE sensor on the sample: 1 – an AE sensor, 2 – a sample 3 – tenzogauge

The scheme of switching the measuring equipment is shown on Figure 4.

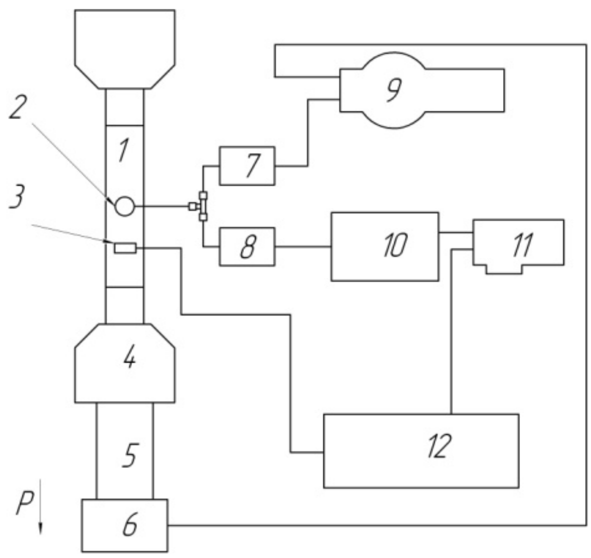


Figure 4. The scheme of switching the measuring equipment: 1 – a sample, 2 – an AE sensor, 3 a tenzogauge, 4 – a clip, 5 – a cylinder, 6 – a dynamometer, 7, 8 – preamps, 9 – PAC POCKET AE – 2, 10 – ГСП АРГУСб 7 АФ-15, 11 – LCard L-783, 12 – a strain gauge system

Loading of samples was carried out due to the following program:

- the three-fold pre-loading to a value of 10 kN or 22 kN for specimens with a longitudinal direction of the fibres and up to 2 kN for specimens with a transverse direction of the fibres, with a subsequent increase in load to destruction the specimen;
- the six-fold pre-loading to value of 6 kN, with a subsequent increase in load to the specimen destruction (Fig. 5.);
- the loading to sample destruction, without pre-loading.

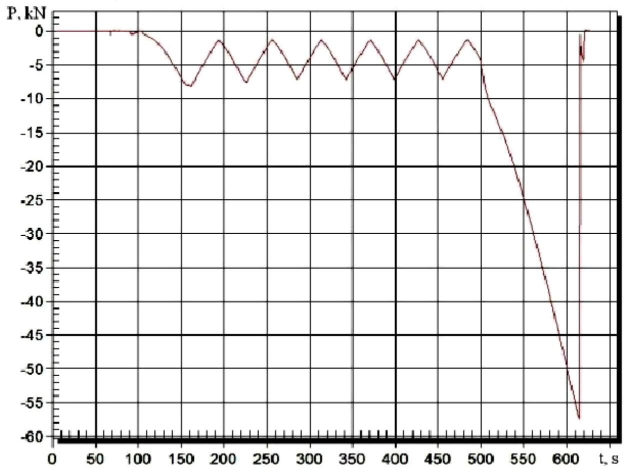


Figure 5. Schedule of sample loading with longitudinal fibres preliminary six-fold loading

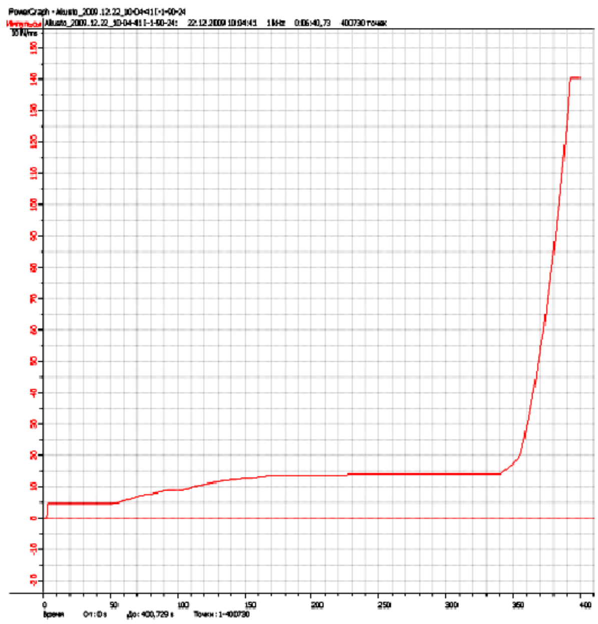


Figure 6. The total of AE signals account versus the time when the specimen was loads with a transverse arrangement of fibres with a preliminary three-times loading

After processing the obtained data were plotted as a function of AE parameters versus load times, as well as the dependence of the parameters of AE on the magnitude of the load (Fig. 6.).

The following relationships were found:

1. During the loading process the amplitude, the duration, the intensity and the energy of AE signals changes its character for the different stages of loading.

2. The relations for each group of samples have a general nature.

The relationships obtained using PAC POCKET AE-2, for ГСП АРГУС-7 АФ-15 show that the nature of the dependences of the intensity of time and loading wore the same character are represented below.

Specimens with longitudinal fibres

At the beginning of the loading process the level of the signal amplitude may achieve for the separate signals of 100 dB, but generally do not exceed 50 dB.

After reaching a load of 60% of the fracture load, the AE amplitude increases to 70 dB, but at the last stage of loading till specimen destruction it reaches 100 dB.

The duration of the AE signal increases from 100 microseconds to 200 mks at the initial stage of loading. After that it increases from 500 mks to 800 mks during 60% of the fracture load, but at the stage of destruction duration of the AE signal reaches 2000 mks.

The intensity of the signals at the initial stage up to 50 after which the signal intensity decreased. At the stage of 15% of the fracture load the intensity is near 10 ms, and with further loading to 60% of the fracture load, it increases to 50. During the destruction of the specimen its value achieves 80.

The values of energy on the initial stage up to 40, at the stage of loading up to 15% of the destructive load the energy reduced to 25, but upon reaching 60% of failure load value of the energy increases to 300, during the destruction of a specimen of its value reaches 5000.

Specimens with transverse arrangement of fibres

The values of the amplitude of the signal the beginning of the loading process may reach for the individual signals 75 dB, but generally does not exceed 50 dB, after reaching a load of 75% of the fracture load the amplitude increases to 70 dB, but at the last stage of loading to the specimen fracture it reached 80–90 dB.

The duration of the signal increases with 50 mks to 200 mks on the initial loading stage, after which increases to 600 during 75% of the fracture load, but at the stage of the destruction the duration of the signal reaches 1000 mks.

The intensity of the signals at the initial stage up to 20, after which at the stage of 10% to 30% of the fracture load the signal intensity decreased of up to 10, with further loading, it rises to 30 at the 75% of the fracture load and at the stage of the specimen failure of its value reaches 60.

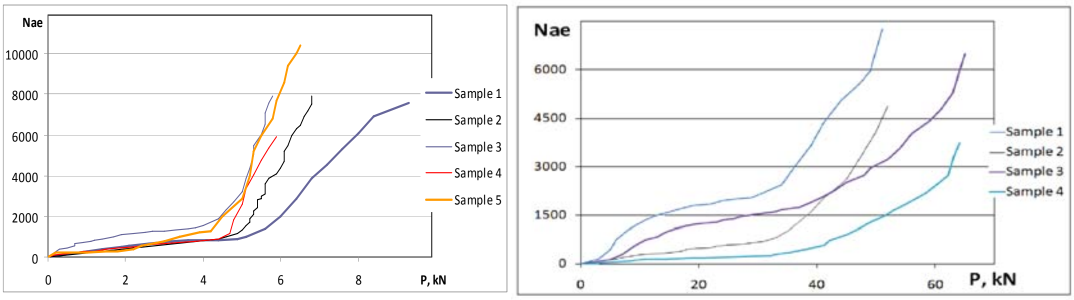
The values of energy at the initial stage is from 40 to 60, at the stage of 30% of the fracture load the energy is reduced to 10, upon reaching 75% of the fracture load value of the energy increases 30–40, and at the stage of destruction of the specimen its value reaches 200.

A clear differentiation processes of loading and fracture in amplitude as in [5], was not found. At the initial stage of loading the values of individual impulses may reach significant values (up to 100 dB), which probably is associated with mounting in the device jaws, specimen clearance (removal of gaps in the jaws with specimens) and the movement of dislocations. During arising the loading the amplitude decreases and do not increases till 60% of the fracture load for specimens with longitudinal fibres and up to 75% for specimens with transverse arrangement of fibres. It's explained by the fact that the acoustic emission signals are formed due to movement of dislocations at this stage. When the load level reach of 60% of the fracture load for the former and 75% for the second, the process of the matrix destruction begins, this is accompanied by signal amplitude from 40 to 60. The next phase is accompanied by the delamination, and is characterized by increasing of the signal amplitude level to 80 dB, the last stage at which the fibre failure is accompanied by the amplitudes of 80 dB to 100 dB. In this case at the last two phases the AE signals with amplitudes characteristic of the matrix destruction are presented.

The destruction of the matrix, the delamination and rupture of fibres are accompanied by increasing AE signals of intensity, duration and energy, while the destruction of the matrix is corresponded to AE signals of lower intensity, duration and energy. During the fracture of fibres AE signals have a maximum intensity, duration and energy, and AE signals during delamination are much greater intensity, duration and energy than that at the destruction of the matrix, but somewhat less than the destruction of the fibres.

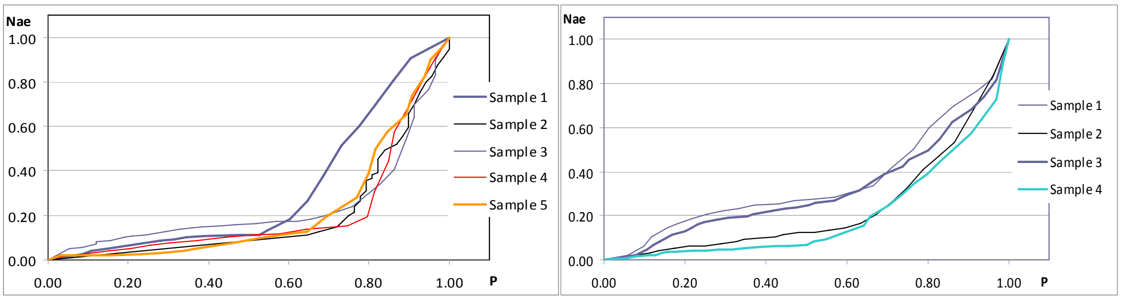
This is most clearly the process of destruction of fibres is characterized by a change in the energy of AE signals as the AE signals at the beginning of the loading process have a small duration.

The obtained dependences of total AE impulses summing versus loading have the same variation of total AE summing for each of the tested specimens: the areas of slow AE signals growth replaced parts of its sharp growth. The intersection of nthese sections forms an angle α, such an angle α, shown in the work of Banov M. and Troenkin D [6].



a) b)

Figure 7. The graph of the AE impulses summing growth versus the loading:
a) specimens with transverse arrangement of fibres, b) specimens with longitudinal fibres



a) b)

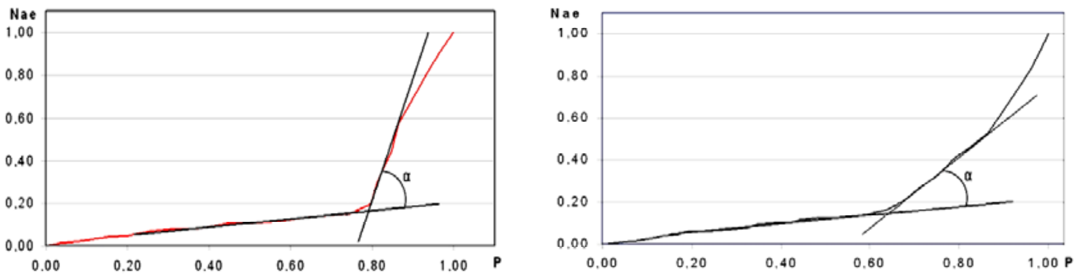
Figure 8. The graph the AE impulses summing growth versus the relative loading:
a) specimens with transverse arrangement of fibres, b) specimens with longitudinal fibres

The formation of this angle α characterizes the beginning of a process of degradation and persists until the fracture.

For specimens with longitudinal orientation of fibres α – change begins from 60 to 70% of the fracture load, describing what the matrix destruction is happens, followed by delamination and finished with the destruction of bearing fibres. Then specimen is completely destroyed.

It is characteristic that for specimens with transverse orientation of fibres that *α*-change begins near 75–80% of fracture load. That characterizes what the matrix material destruction is happened, followed by delamination and finished with the destruction of connecting fibres, after which the specimen is completely destructed.

Thus the method of acoustic emission allows determining the start of an irreversible failure of unidirectional composite material.



a) b)

Figure 9. The graph of the relative the AE impulses summing growth versus the relative loading:
a) specimens with transverse arrangement of fibres, b) specimens with longitudinal fibres

Conclusions

In the specimens with longitudinal orientation of fibres relative to the applied load the beginning of destruction observed under 60% of the destructive load values is exceeded.

In the specimens with transverse orientation of fibres relative to the applied load the beginning of destruction observed under 75% of the destructive load values is exceeded.

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Transport and Telecommunication, 2010, Volume 11, No 2
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CUMULATIVE INDEX

TRANSPORT and TELECOMMUNICATION, Volume 11, No 2, 2010 (Abstracts)

Yatskiv, I., Pticina, I. Construction of the Urban Public Transport System's Quality Indicator with Missing Data, *Transport and Telecommunication*, Vol. 11, No 2, 2010, pp. 4–11.

The purpose of this investigation is the development of transport system's quality indicator – UPTQI (urban public transport quality indicator) calculation methods where some values are missing in the data set. As a quality indicator, the indicator accumulating the information about urban public transport system – composite indicator is used. The algorithm described in [1] has been used for developing the composite indicator. The special accent is made on a choice of a missing data imputation method in an initial data set and on stability of results. It is not possible to make the unequivocal recommendation for use concrete method in the presence of a large number of offered methods. In many respects it depends on the initial data. The initial data concerning the cities of Europe were taken from EUROSTAT database [2]. The 8 sub-indicators for 2006 have been used for constructing the UPTQI.

The research was divided into three stages. At first, artificial missing data was introduced, and investigated the influence of the 3 selected methods of missed data substitution (unconditional mean imputation, imputation by median and clustering-based imputation) upon the results of composite indicator calculation. In the next stage the cities with the missing data have been added (in total 62 European cities). The method which is chosen as the best for this problem during the first stage has been used to the missing data imputation. To calculate the weights and to aggregate the same variants of algorithm, as at the first stage were used. At the last the results of UPTQI constructing were analysed for uniformity.

Keywords: public transport, quality, composite indicator, weights, missing data, imputation

Girvica, O. Optimisation of the Supply Chain Process for the Logistics Centre, *Transport and Telecommunication*, Vol. 11, No 2, 2010, pp. 12–17.

In this paper the problem of decision-making process for creation of the new supply and distribution channel of the Logistics centre is observed. The task consists in decision-making regarding the way selection from choosing the raw materials till final products creation that allows getting the maximum profit to the company.

This task could be solved by using the method of dynamic programming. In this case it means to make decision for each unit individually.

The solution of the real task for Logistics centre in Latvia is observed in this paper as the numerical sample of decision-making process for the new supply and sales channel development in order to get the maximum profit for the Logistics centre.

Keywords: decision- making, supply chain, dynamic programming.

Grakovski, A., Murza, A. Development of Segmentation Method Based on "Mass Centre" Approach for Video Surveillance Data of Transport Vehicles Flow, *Transport and Telecommunication*, Vol. 11, No 2, 2010, pp. 18–29.

The increasing traffic in the European Union puts in the forefront the need to create intelligent transport systems of traffic control (ITS) at district, urban and regional scale. Structurally, such systems include a network of sensors of primary or indirect measurements of traffic flows, a control centre and a network of executive components (traffic lights, controlled traffic signs, reversible lanes, etc.). The wider the network of sensors, the more complete information is available for high quality of the intelligent control. Currently, video, laser, radio frequency, induction, and pressure sensors are mainly used as sensors of traffic flows' parameters. The deployment of a network of such sensors requires significant financial resources, and sometimes also additional construction work. Installation, maintenance and protection of an expensive network of sensors and their channels of communication make the creation of full-scale ITS rather expensive, which is not affordable at all.

The possibility of using mobile video detection system to measure traffic is discussed. This mobile system consists of a notebook and simple web-camera, which is the cheapest version of the video sensor. Video data processing is done by stages: detection, segmentation, classification and tracking. Algorithm for finding and identifying vehicles on each frame of video stream is proposed. Algorithm is based on finding "mass centre" of all "good features" on each video frame. This allows identifying vehicles and helps to escape noise and unwanted motions on the frame. Tracking of "mass centre" and other properties allows identifying transport vehicles during motion through the view port. Different cases of transport vehicle mutual intersection are processed.

Keywords: segmentation, computer vision, detection, tracking, transport vehicles

Griškevičiūtė-Gečienė, A., Griškevičienė, D., Griškevičius, A. Methodological Features Regarding the Prognostication of Lithuanian Railway Freight Transport Volumes from a Long-Term Perspective, *Transport and Telecommunication*, Vol. 11, No 2, 2010, pp. 30–43.

The prognostication of Lithuanian Railway freight transport volumes from a long-term perspective is difficult methodological process even during a period of positive economic development. All sectors of National Economy have serious consequences of international crises and still are not recovered (did not climb out of economic recession). Therefore it is not a time to predict further optimistic development. Social sector having influence on a usage and a growth of its demand is still in more complicated situation. Despite of this unpleasant economic situation the processes of projection, strategic planning, and preparation of priority projects, investment planning and implementation continue to proceed.

That determines urgent modelling of separate economic sectors, forecasting of specific activities and preparation of tactical plans. This attitude was a basis for the methodology regarding prognostication of railway freight and passenger transport volumes from a long-term perspective. Necessity of preparation of priority infrastructure projects and substantiation of their decision determines the period of perspective.

Keywords: railway freights volume, transport flows, DGP projections, providences of the economic development, influence of internal and external factors, forecast of macroeconomic indicators

Krasnitsky, Yury A. Lightning Stroke Passive Location by Atmospherics Analysis in the Hop Model Frames, *Transport and Telecommunication*, Vol. 11, No 2, 2010, pp. 44–49.

The problem of lightning location from single station observation is considered based on the hop model of lightning electromagnetic radiation pulse propagation in spherical waveguide "Earth – ionosphere". Some new methods are discussed to estimate the delays of the ionosphere reflected waves with respect to the ground wave. These delays give raise to the undetermined system of equations where unknown quantities are the distance and the effective reflecting heights of ionospheric waves. Some methods to remove the uncertainty based on approximation of difference of effective reflecting heights are considered. Program codes in Matlab to process atmospherics are developed. Proper examples concerning of really registered signals are carried out.

Keywords: thunderstorm, lightning, electromagnetic radiation, atmospherics, hop model, ionospheric waves, delays, distance evaluation

Novák Sedláčková, A., Novák, A. Simulation at the Bratislava Airport after Application of Directive 2009/12/EC on Airport Charges, *Transport and Telecommunication*, Vol. 11, No 2, 2010, pp. 50–59.

The Directive on Airport Charges-Directive 2009/12/EC was issued in March 2009 by European Parliament and the Council. It is a common framework regulating the essential features of airport charges. EU presents the necessity of economic regulation of airports and airport charges in Europe, but is the economic regulation the right way for Bratislava Airport and airports in the similar position? This paper explains the situation of Slovak airports and their approach to economic regulation of airport charges. The paper describes the simulation of situation at the Airport Bratislava after application of a regulation formula of economic regulation of airport charges considered as the most appropriate for Slovak airports especially Airport Bratislava. The regulation formula is based on the research of the authors.

Keywords: directive of EU, airport charges, simulation, regulation formula, Slovak airports

TRANSPORT and TELECOMMUNICATION, 11.sējums, Nr.2, 2010 (Anotācijas)

Jatskiva, I., Pticina, I. Pilsētas sabiedriskā transporta sistēmas kvalitātes rādītāja ar iztrūkstošiem datiem konstruēšana. *TRANSPORT and TELECOMMUNICATION,* 11.sēj., Nr.2, 2010, 4.–11. lpp.

Dotā pētījuma mērķis ir transporta sistēmas kvalitātes rādītāja UPTQI (*angl.* – urban public transport quality indicator) aprēķina metožu izstrāde, kur datu rindā pietrūkst dažu vērtību. Kā kvalitātes rādītājs, rādītājs, kurš akumulē informāciju par pilsētas sabiedriskā transporta sistēmu – tiek lietots kompozīts rādītājs. Algoritms, kas aprakstīts [1] ir lietots, lai izstrādātu kompozīta rādītāju. Īpašs uzsvars tiek likts uz piedēvēšanas metodes iztrūkstošo datu izvēli sākotnējā datu rindā, kā arī uz rezultātu stabilitāti. Ir neiespējami izveidot nepārprotamu rekomendāciju konkrētas metodes lietojumam, klātesot lielam skaitam piedāvāto metožu. Daudzējādā ziņā tas ir atkarīgs no sākotnējiem datiem. Kas attiecas uz Eiropas pilsētām, sākotnējie dati tika ņemti no EUROSTAT datubāzes [2]. Astoņi subindikatori 2006. gadā tika izmantoti UPTQI konstruēšanai.

Pētījums ir sadalīts 3 posmos. Vispirms tika ievadīti mākslīgi iztrūkstošie dati un izpētīta izlaisto datu aizvietošanas 3 izvēlēto metožu (beznosacījumu vidējā pārdēvēšana, pārdēvēšana ar mediānu, pārdēvēšana bāzēta uz klasteri) ietekme uz kompozīta rādītāja aprēķina rezultātiem. Nākamajā posmā pilsētas ar iztrūkstošiem datiem tika pievienotas (kopumā 62 Eiropas pilsētas). Metode, kura ir izvēlēta kā labākā šai problēmai, pirmā posma laikā tika lietota iztrūkstošo datu pārdēvēšanai. Aprēķināt apgrūtinājumus un apkopot tos pašus algoritma variantus kā tajā pašā posmā tika lietoti. Visbeidzot, UPTQI konstruēšanas rezultāti bija analizēti vienveidībai.

Atslēgvārdi: sabiedriskais transports, kompozīta rādītājs, apgrūtinājumi, iztrūkstošie dati, pārdēvēšana

Girvica, O. Piegāžu ķēdes procesa optimizācija loģistikas centram. *TRANSPORT and TELECOMMUNICATION,* 11.sēj., Nr.2, 2010, 12.–17. lpp.

Dotajā rakstā ir izskatīts lēmumu pieņemšanas process Loģistikas centra jaunu piegāžu un sadales tīkla radīšanai. Uzdevumu sastāda lēmumu pieņemšana izejmateriālu izvēlē līdz pat beigu produkta radīšanai, kas pieļauj sasniegt maksimālo labumu kompānijas interesēs.

Šis uzdevums var tikt atrisināts ar dinamiskās programmēšanas metodes pielietošanu. Šajā gadījumā tas nozīmē pieņemt lēmumu katrai vienībai atsevišķi.

Dotā uzdevuma atrisināšana Loģistikas centram Latvijā tiek apskatīts šajā rakstā kā skaitlisks piemērs lēmumu pieņemšanas procesā jaunām piegādēm un tirdzniecības tīklu izveidei, lai iegūtu maksimālo profitu.

Atslēgvārdi: lēmumu pieņemšana, piegāžu ķēde, dinamiskā programmēšana

Grakovskis A., Murza, A. Segmentācijas metodes izstrāde, pamatota uz „*Mass centre*” pieeju transportlīdzekļu plūsmu video novērojumu datiem. *TRANSPORT and TELECOMMUNICATION,* 11.sēj., Nr.2, 2010, 18.–29. lpp.

Pieaugošā satiksmes attīstība Eiropas Savienībā rada nepieciešamību izstrādāt satiksmes kontroles saprātīgu transporta sistēmu kā rajona, pilsētas, tā arī reģionālajā līmenī. Strukturāli šādas sistēmas ietver primāru un netiešu satiksmes plūsmu mērījumu sensoru tīklu, kontroles centru un izpildu komponentu tīklu (satiksmes gaismas, satiksmi kontrolējošās zīmes, reversīvas joslas utt.). Jo sensoru tīkls ir plašāks, jo pilnīgāka informācija ir pieejama augstas kvalitātēs inteliģentai kontrolei. Pašlaik kā satiksmes plūsmu parametru sensori galvenokārt tiek lietoti video, lāzeru, radio frekvenču, indukcijas un spiediena sensori.

Lai vērtētu satiksmi, autori rakstā iztirzā arī mobilo video uztveršanas sistēmas iespēju. Šī mobilā sistēma sastāv no piezīmju grāmatas un vienkāršas web-kameras, kas ir vislētākā video sensora versija. Video datu apstrāde tiek veikta posmos: uztveršana, segmentācija, klasifikācija un izsekošana. Rakstā tiek piedāvāts transportlīdzekļu atrašanas un identifikācijas algoritms katrā video plūsmas kadrā. Algoritms tiek pamatots uz visu „labo īpašību” „masu centra” atrašanu katrā video kadrā. Tas ļauj identificēt satiksmes līdzekļus un palīdz izvairīties no trokšņa un nevajadzīgām kustībām kadrā.

„Masu centra” izsekošana un citas īpašības ļauj identificēt transporta līdzekļus kustību laikā caur skata portu. Tiek apstrādāti transporta līdzekļu savstarpējās krustošanās dažādi gadījumi.

Atslēgvārdi: segmentācija, datora vīzija, uztveršana, izsekošana, transporta līdzeklis

Griškevičūte-Gečiene, A., Griškevičiene, D., Griškevičus, A. Metodoloģiskas iezīmes lietuvas kravas transporta apjoma prognozēšanā ilgtermiņa perspektīvā. *TRANSPORT and TELECOMMUNICATION,* 11.sēj., Nr.2, 2010, 30.–43. lpp.

Lietuvas dzelzceļa kravas pārvadāšanas apjoma prognozēšana ilgtermiņā ir grūts metodoloģisks process pat labvēlīgas ekonomiskas attīstības periodā. Visiem sektoriem Nacionālajā Ekonomikā ir nopietnas konsekvences pēc starptautiskās krīzes un joprojām tā nav atguvusies (nav tikusi ārā no ekonomiskas lejupslīdes). Tādēļ šis nav īstais brīdis paredzēt tālāku optimistisku attīstību. Sarežģītā situācijā atrodas arī sociālais sektors. Par spīti šai nepatīkamai situācijai joprojām turpinās projektēšana, stratēģiskā plānošana un sagatavošanās prioritārajiem projektiem, kā arī investīciju plānošanas un ieviešanas darbi.

Tas nosaka steidzamu atsevišķu ekonomikas sektoru modelēšanu, specifisku aktivitāšu prognozēšanu un sagatavošanos taktiskiem plāniem. Šis raksts ir metodoloģijas pamats dzelzceļa kravas un pasažieru pārvadājumu apjomu prognozēšanā ilglaicīgā periodā. Prioritāru infrastruktūras projektu sagatavošanas nepieciešamība un to lēmumu pamatojums nosaka perspektīvas periodu.

Atslēgvārdi: dzelzceļa kravas apjoms, transporta plūsmas, makroekonomisko rādītāju prognozēšana

Krasnitskis, J. A. Zibens šautras inerts izvietojums pēc atmosfēras analīzes hop-modeļa ietvaros. *TRANSPORT and TELECOMMUNICATION,* 11.sēj., Nr.2, 2010, 44.–49. lpp.

Tiek izskatīta zibens izplatības problēma no vienas novērošanas stacijas, pamatojoties uz zibens izplatīšanos hop-modeļa elektromagnētiskās radiācijas impulsu sfēriskajā viļņu vadāmā caurulē „Zeme – jonosfēra”. Tiek diskutētas dažās jaunas metodes, lai novērtētu jonosfēras atstaroto viļņu aizkavēšanos, ņemot vērā pamata vilni. Šīs aizkaves izraisa vienādojumu nenoteikto sistēmu, kur nezināmie daudzumi ir distance un jonosfēras viļņu efektīvie atstarojošie augstumi. Dažas metodes, lai izgaistu nenoteiktība, tiek pamatotas uz efektīvo atstarojošo augstumu atšķirību aproksimāciju. Tiek izstrādāti MatLab programmas kodi atmosfēras norisēm. Tiek izstrādāti piemēri pēc precīzi reģistrētiem signāliem.

Atslēgvārdi: vētra, zibens, elektromagnētiskā radiācija, atmosfēra, hop-modelis, jonosfēras viļņi, attāluma novērtējums

Novak Sedlačkova, A., Novak, A. Simulācija bratislavas lidostā pēc 2009/12/EK direktīvas par lidostas cenām, *TRANSPORT and TELECOMMUNICATION,* 11.sēj., Nr.2, 2010, 50.–59. lpp.

Eiropas Parlaments un Padome lidostas cenu direktīvu 2009/12/EK izdeva 2009.gada martā. Tā ir kopēja struktūra, kas regulē lidostu cenu pamatiezīmes. ES piedāvā lidostu ekonomiskās regulēšanas nepieciešamību un lidostu cenas Eiropā, bet vai šie ekonomiskie regulējumi ir pareizais ceļš Bratislavas lidostai un citām lidostām līdzīgā situācijā? Autore šajā rakstā izskaidro patieso situāciju Slovākijas lidostās un to pieeju lidostu cenu ekonomiskajam regulējumam. Rakstā tiek simulēta situācija Bratislavas lidostā pēc lidostas cenu ekonomiskā regulējuma formulas pielietošanas, kas tiek uzskatīta kā vispiemērotākā Slovākijas lidostām, īpaši Bratislavas lidostai. Regulēšanas formula tiek pamatota uz autoru pētījumu rezultātiem.

Atslēgvārdi: ES direktīvas, lidostu izmaksas, simulācija, regulēšanas formula, Slovākijas lidostas

Orlovs, S., Ciļkers, B. Borta kompjūtersistēmu efektivitāte gaisa kuģiem un stacijām. *TRANSPORT and TELECOMMUNICATION,* 11.sēj., Nr.2, 2010, 60.–67. lpp.

Darbā tiek apskatītas kompleksā efektivitātes novērtējuma borta kompjūtersistēmu metodes gaisa kuģos un stacijās.

Šādam novērtējumam autori piedāvā mehānisko apstrādi: efektivitātes kritērijus un darbību tempa etalona vektorus, ņemot vērā borta kompjūtersistēmu funkcionēšanas un uzbūves specifikāciju.

Atslēgvārdi: efektivitāte, efektivitātes kritērijs, kontroles uzdevumi un algoritmi, instrukciju rinda, izpildījums, vidējais ātrums, etalona darbību biežuma vektors

Urbahs, A. Banovs, M., Harbuz, Y., Turko, V., Feščuks, J., Hodos, N. Anizotropas armētas plastmasas mehāniskas īpašības noteikšana ar akustiskas emisijas metodes pielietošanu, *TRANSPORT and TELECOMMUNICATION,* 11.sēj., Nr.2, 2010, 68.–75. lpp.

Rakstā tiek iztirzāti kompozīta materiāla (anizotropas armēta plastmasas tipa) mehānisko īpašību novērtēšanas rezultāti.

Testu noslodze tiek pielietota uz paraugiem ar armētas šķiedras ievirzi attiecībā pret slodzes virzienu garengriezumā vienā gadījumā un šķērsgriezumā otrā gadījumā. Paraugi statiskā sprieguma testiem tiek lietoti kā kvadrāta formas apmale ar veidojumu fiksētām plāksnēm abos galos, lai montētu testa ierīces caurumotajās knaiblēs. Statiskā testa programma sastāv no trīs- līdz sešas reizes paraugu slogojuma līdz 20% no maksimālā noslogojuma līmenim: pēc tam noslogojums ir bezgalīgs līdz paraugu sabrukumam.

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Atslēgvārdi: akustiskā emisija, kompozītmateriāli, izmēģinājumi, slogošana, matrica

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20. ***Acknowledgements***
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