Transporta un sakaru institūts
(Transport and Telecommunication Institute)

Transport and Telecommunication

Volume 10, No 4 - 2009

ISSN 1407-6160
ISSN 1407-6179
(On-line: www.tsi.lv)

Riga – 2009

Host Organizations:
Transport and Telecommunication Institute, Latvia – Eugene Kopytov, Rector
Telematics and Logistics Institute, Latvia – Igor Kabashkin, Director

Supporting Organizations:
Latvian Transport Development and Education Association
Latvian Academy of Sciences
Latvian Operations Research Society
Telecommunication Association of Latvia
Latvian Academic Park

All articles are reviewed.
Articles can be presented in the journal in English.

EDITORIAL CORRESPONDENCE

Transporta un sakaru institūts (Transport and Telecommunication Institute)
Lomonosova iela 1, LV-1019, Riga, Latvia. Phone: (+371)67100594. Fax: (+371)67100535.
E-mail: kiv@tsi.lv, http:// www.tsi.lv

TRANSPORT and TELECOMMUNICATION, 2009, Vol. 10, No 4
ISSN 1407-6160
The journal of Transport and Telecommunication Institute (Riga, Latvia).
The journal is being published since 2000.

The papers published in Journal “Transport and Telecommunication” are included in **SCOPUS** (since 2008, Vol. 9, No 1), **Elsevier Database**
www.info.scopus.com
www.elsevier.com

CONTENTS

Transport and Telecommunication, 2009, Volume 10, No 4, 4–7
Transport and Telecommunication Institute, Lomonosova 1, Riga, LV-1019, Latvia

PRESENT SITUATION OF HEAVY GOODS TRAFFIC IN LITHUANIA

Ramūnas Palšaitis[1], Artūras Petraška[2]

Vilnius Gediminas Technical University
Plytines 27, Vilnius, LT-10105 Lithuania
E-mails: [1]trvadyba@ti.vgtu.lt, [2]arturas@transvelas.lt

The article describes the heavy goods transportation situation in Lithuania. The emphasis is placed to determine the reasons which cause the problems of heavy goods transportation. Shippers and the transport companies which are organizing heavy goods transportation confront with the shortage of especial vehicles and handling equipment, high cost of transportation, high charges, imperfect legal base and awkward behaviour and bureaucracy of governmental institutions.

Keywords: heavy goods, transportation, costs, transportation environment

1. Introduction

During the last decade Lithuania implements economic reforms, which aim – to consolidate the state and to create Lithuania's economy competitive in world markets. Restructuring and strengthening processes of transport, industrial and energy sectors also make changes in goods and services markets. The economy of Lithuania is highly dependents on the existence of freight network capable of efficiently moving raw materials, components and finished goods from the point of manufacture and supply to the final customer. The multivariate nature of customer service and different requirements of specific markets is essential for any business to have a clearly identified policy towards customers' service. Therefore, the transport companies which are organizing the international and local cargo transportation are trying the clients' safe and fast transportation service.

The most important factor affecting the quality of transportation heavy goods is security. The quality of transportation of such goods is related with companies' ability for quick and cost effective transportation process. This result can be achieved with efficiently working employees, customized vehicles and suitable transport infrastructure for transportation heavy goods.

2. Current Situation of Heavy Goods Transportation in Lithuania

Technological and industrial development is very often connected with the heavy goods transportation. International and local transportation of heavy goods is regulated of set of legal acts.

Transportation process of heavy goods consists of acceptance of the cargo from shipper, transportation and it's delivery to the customer. Also this process is related with the route selection, acquisition of permits, loading, reloading and unloading processes and temporary storage if it's necessary. It is important to define the particularity and the technical characteristics of heavy goods. Heavy goods can be classified as oversize and heavyweight. Oversize is determinable by standards and assessment of transport infrastructure which is used for goods transportation. Infrastructure consists of road equipment, buildings, various signs and other road infrastructure elements. Therefore, transport mode infrastructure determines what goods can be transported with the smallest negative impact to it. The standard size of vehicle is settled by the legal acts for the each transport mode. The other situation is with the term of "heavyweight". The road vehicle is identified as heavyweight when the total weight of it (with cargo or without it) is more than 40 tones or maximal load on at least one axle exceeding 10 tones. Definition of "heavyweight" may be amendment frequently. It could be changed by the laws.

Transportation of heavy goods by road is very expensive, because:

- Road technical characteristics often are not appropriate for transportation of goods;
- It takes quite long time to get needful permits;
- Costs of permits are quite high;
- It is difficult to find appropriate technical devices for transportation.

Currently in Lithuania cost of heavy goods transportation permits is quite high and many companies are risking transporting such shipments without permits. In Lithuania it is possible to transport goods without special permits if the vehicle satisfy EU requirements (height – 4 meters, width – 2,55 meters, overall length – 16,50 meters, total weight – no more than 40 tones).

Lithuania State Road Transport Inspection inspectors in 2008 (March 1–31) weighed and measured 76 vehicles, of which 19 exceeded the allowable total weight, 21 exceeded the axle (s) load, 16 vehicles exceeded the maximal overall length. In 2009 (March 1–31) were weighed and measured 446 vehicles, of which 12 exceed the allowable total weight, 13 exceed the axle load, 5 vehicles exceeded the maximal overall length. The drivers of these vehicles paid penalties. Inspection results show that the penalties for heavy goods transportation is much lower than the costs of the permits. Number of the permits which were given to the transport companies for the transportation of heavy goods is shown in the table 1.

Table 1. Number of permits for heavy goods transportation

Year	Number of given permits
2007	5340
2008	7351
2009 (within 8 months)	3919

Each heavy goods transportation case is unique. 13,6 meters long trailers not always could be used for transportation. It's necessary to have special longitudinal or humiliated trailers. Commonly Lithuanian carriers are transporting:

- Reinforced concrete (beams, slabs, columns etc.);
- Industrial equipment;
- Heavy machining equipment, tractors;
- Various size liquid containers;
- Metal or wood constructions;
- Wind turbines.

If the heavy load shipper or transport company is planning to transportation heavy load it must collect such information:

- Total weight (vehicle + cargo);
- Loaded vehicle dimensions;
- Load weight;
- Route;
- Number of vehicle wheels and axles;
- Axle loads;
- The largest single axle load.

During the transportation of very heavy and oversize goods it is necessary to have escort, specially prepared vehicles in front and in the back of the truck. The route of transportation must be examined in detail in order to avoid potential negative obstacles to the heavy cargo during the transportation process. In some cases, tracing of cargo may be accompanied by several police officers.

Many Lithuanian carriers are refusing to transport heavy goods for these reasons:

- Shortage of equipment for transportation such loads;
- Complicated legal regulation, quantity of documents;
- High own transportation costs;
- Staff incompetence or lack of experience;
- Additional time costs;
- Insufficient heavy goods market.

On the other hand, describing the current heavy goods transportation process it's possible to distinguish three integrated environments. Analyses of these environments, which directly affect transportation process of such loads, describe main problems of such transportation. The existing heavy goods transportation organization model is presented in figure 1. Relations between the elements are shown in figure 2.

In the Fig. 2 arrows indicate the links between cells, which shows that these environments are interrelated and can not be distinguished. The largest influence on other elements of the environment has legislative instruments. In particular, they set and coordinate institutions activities, permits acquisition, definitions of "oversize" and "heavy goods".

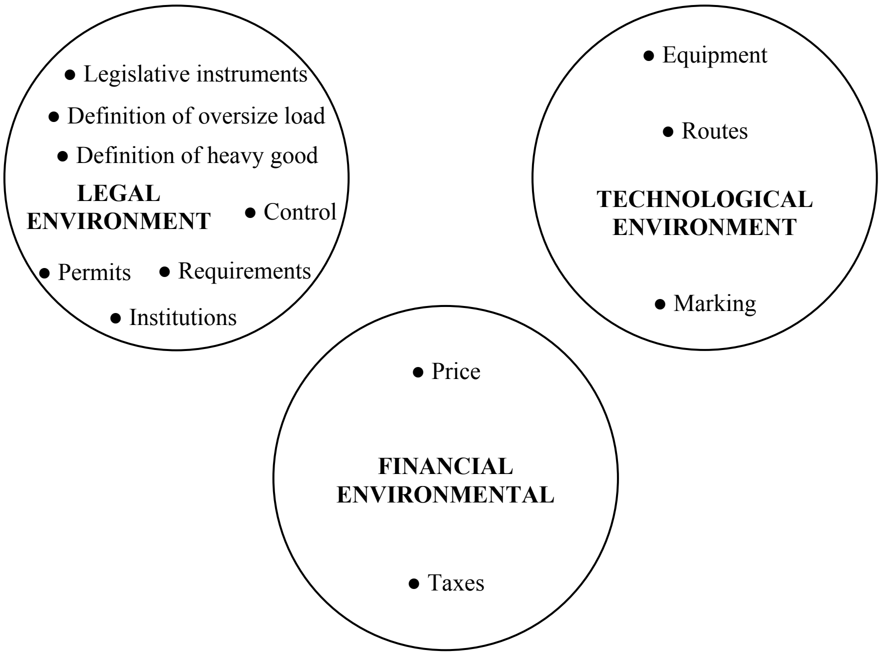


Figure 1. Existing heavy goods transportation organization model

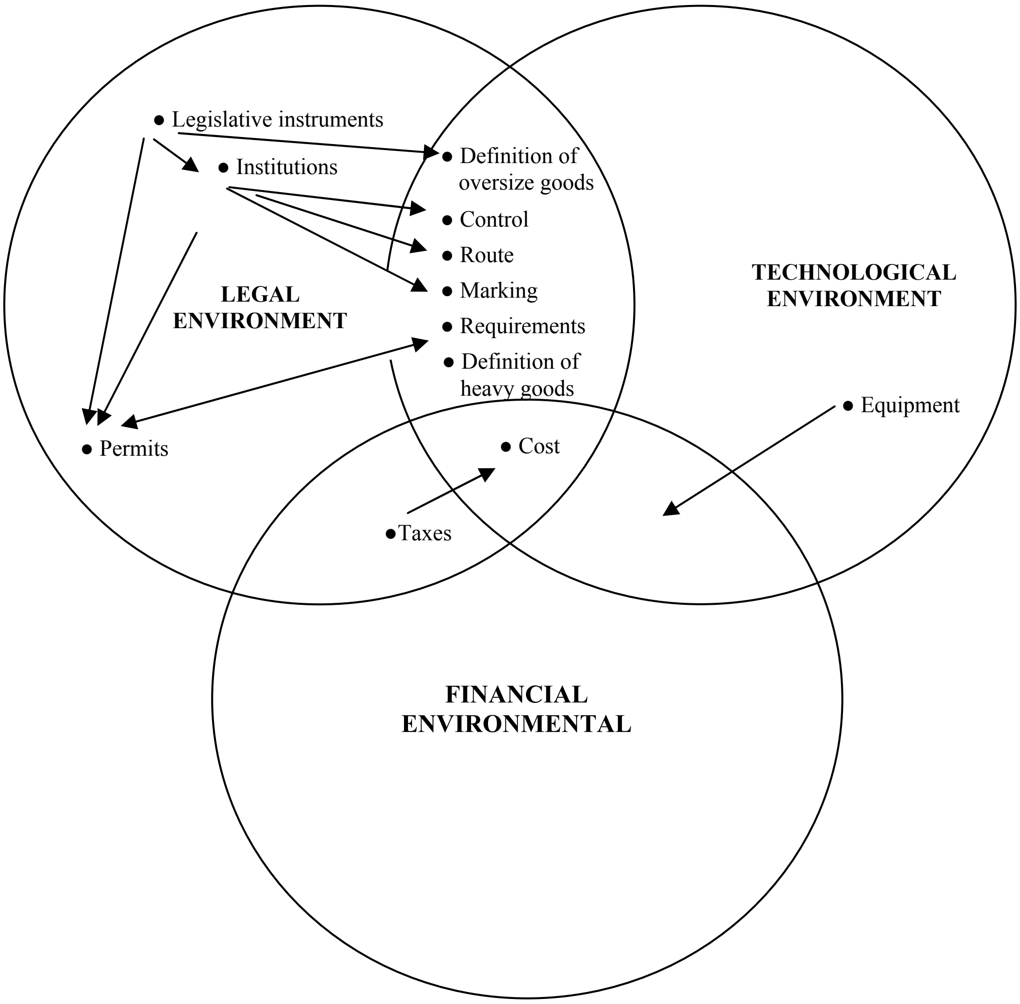


Figure 2. Environment of heavy goods transportation constituent elements and relations between them

Common to all three environmental elements, is price. The transportation cost of heavy goods consists of transportation cost profit which company expects to receive. Price is related to technological environment. Special equipment for transportation heavy goods is very expensive and it also influences the final cost of transportation. Taxes, which company should pay for transportation of heavy goods, are also one of the components which influence the cost of transportation. Therefore, it can be argued that the cost is related with the technological, financial and legal environments. It is identified, that in Lithuania heavy goods transportation cost mostly depends on legislative instruments.

3. Prospects of Heavy Goods Transportation in Lithuania

Transportation of heavy goods in Lithuania has scarcely ever been analyzed. Technological, industrial development is an integral part of heavy goods transportation. Currently is very important for Lithuania to find a solution and the best transport corridors for heavy goods shipments from West part to the East part of the country. Plans of new nuclear power stations in Lithuania and Belarus building and projects for network of wind turbines as alternative energy source will influence in heavy goods transportation increase in the nearest future. That's why it's necessary to make deep analysis of Lithuania transport system (Klaipeda seaport, railways, road transport, internal water transport) and inspect all possibilities of transportation such oversize loads.

Usually heavy goods to Lithuania are delivered by sea. The first point which is important for such shipments is Klaipeda sea-port. From sea-port start all other transport modes, which could be useful for carrying not standard loads. The possibilities of transportation of heavy goods by road, railways, inland waterways and trans-shipping of the heavy goods in Klaipeda State Seaport must be inspected. This analysis will help to find the best solution how in cheapest way to transport heavy goods using possibilities of multimodal transport operations.

4. Conclusions

1. The quality of heavy goods transportation is related with companies' ability for quick and cost effective transportation process.
2. The cost of heavy goods transportation is related with the technological, financial and legal environments.
3. It is identified, that in Lithuania heavy goods transportation cost mostly depends on legislative instruments and juridical basis.
4. Currently for Lithuania it is very important to find solutions and the best transport corridors for heavy goods transportation from West part to the East part of the country and for the transit to Belarus and Poland.

References

1. Bazaras, D., Palšaitis, R. Research's aspects of logistics service development. *The international conference "Reliability and statistics in transportation and communication"* (RelStat'04), 14–15 October 2004 Riga, Latvia: Programme and Abstracts. Riga: Transport and Telecommunication Institute, 2004. ISBN 9984-668-76-2. 113 p.
2. Palšaitis, R., Šakalys, A. Development of Intermodal Transport in New European Union States. *Transport Journal of Vilnius Gediminas Technical University and Lithuanian Academy of Science.* 2006, Vol XXI, No 2, 148–153 p. ISSN 1648-4142.
3. *Manual for international transport*. Vilnius: LINAVA, 2009.
4. Cole, S., Palsaitis, R. Present situation and future demand of the Lithuanian intermodal transport terminals. *Proceedings of 11th International Conference. Transport Means.* KTU. Kaunas. 2007. Lithuania. 245–247 p. ISSN 1822-296X.
5. Litvinenko, M., Palšaitis, R. The evaluation of transit transport probable effects on the development of country's economy. *Transport*. ISSN 1648-4142. Vol. 21, No 2 (2006). p. 135–140.

Transport and Telecommunication, 2009, Volume 10, No 4, 8–17
Transport and Telecommunication Institute, Lomonosova 1, Riga, LV-1019, Latvia

SPATIAL COMPETITION PRESSURE AS A FACTOR OF EUROPEAN AIRPORTS' EFFICIENCY

Dmitry Pavlyuk

Transport and Telecommunication Institute
Lomonosova Str. 1, Riga, LV-1019, Latvia
Ph.: +371 29958338. E-mail: Dmitry.Pavlyuk@tsi.lv

This study deals with estimation of European airports' efficiency values and their interrelation with a level of competition pressure for passengers among airports.

In this paper a new adaptive definition of airport's catchment area is presented. Using this definition we develop an indicator of a level of competition pressure, based on overlapping of airport's potential catchment areas.

A stochastic frontier model to estimate efficiencies of airports is applied. The method includes the construction of a production frontier for a sample of airports and estimation of individual airports' efficiency values as distances from this frontier. A classic production approach to airport activities where an airport enterprise uses labour resources (a number of employees) and infrastructure (a number of runways, gates, check-ins and parking spaces) for transportation of passengers is discussed. A re-sampling jack-knife technique to test the reliability of airports' efficiencies estimates is used as well.

A relationship between a level of competition pressure and airports' operation efficiencies in case of imperfect spatial competition for passengers has been investigated.

Keywords: stochastic frontier, efficiency, airport, spatial competition

1. Introduction

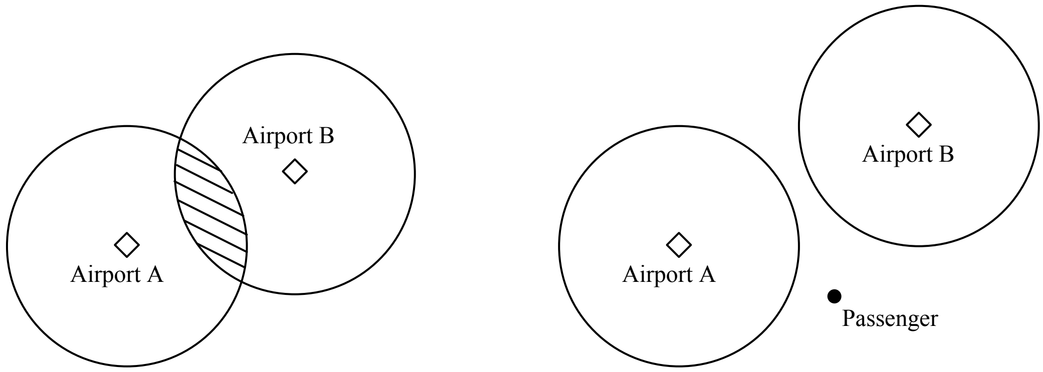
A relationship between a level of market competition pressure and efficiency of economic units' activities is one of the foundation stones of the economic theory. The market of air carriage is not an exception, and the common rules should work there, but the competition pressure has some specifics.

There are two main competition areas for a company – competition for suppliers and competition for customers. For airport companies suppliers are a set of service providers, the main of which are airlines, and customers are potential air passengers. Competition for airlines is very important for airports, but it can be considered as a standard one from a theoretical point of view. In this area we can consider conditions for landing/maintenance, contact agreements, discounts, etc. – the usual set for competition for suppliers. But the competition for passengers has some features, and the main of them is related with a location of airports. The spatial nature of competition for passengers makes it interesting for researches.

The theory of airport competition for passengers is based on a conception of airport catchment areas (or hinterlands). A catchment area is "a geographical zone containing the potential users and passengers for the airport" [1]. The main reason for competition in this approach is unalterable locations of airports. Usually airport's catchment area is calculated on the base of a distance from the airport (for example, 100 kilometres area around the airport). A better approach uses a travel time instead of a distance (for example, a zone where a travel to the airport takes less than 2 hours) [2].

Overlapping of airports' catchment areas is a considered source of competition pressure [3]. The conception is presented on the Figure 1. Airport A and B compete for passengers living in the overlapping area (a shaded area on the Figure 1.A), and bigger overlapping area (relatively to airport's catchment area) means higher competition pressure. The situation B on the Fig.1 (labelled "No competition") is also frequently considered in literature, but looks as non-natural from our point of view. The nature of competition is based on availability of a number of alternatives, and if a passenger has no other alternatives, but he needs for airport services – he will have to travel to the nearest airport even if he is not living in airport's catchment area (the "Passenger" point on the Fig.1) and will spend 3-4 (or even more) hours to reach it. So the classical approach to catchment areas as a circle with a predefined radius is not working in this case, and in this research we suggest a correction for catchment area definition.

Another complication of catchment areas is related with services provided by airports. Each airport has its own "range of goods" – flights to different destination points with different frequencies. If one airport provides flights to a selected destination, and another one does not – the catchment area for this destination of the first airport will be enlarged, the catchment area of the second airport will be joined to the first. Destination points as usual goods have an interchange ability property, for example, in some cases flights to Munich can be replaced with flights to Frankfurt. A frequency of flights also makes a difference.



Situation A. Competition for passengers in the overlapping area

Situation B. No competition

Figure 1. Spatial competition among airports

In this research a method to calculate a level of competition pressure on the base of catchment areas overlapping subject to all listed complexities is suggested.

One of the main economic advantages of the competition is increasing of efficiency of activity of economic units. The researcher uses a stochastic frontier model [4] to estimate efficiencies of European airports and its interrelation with a level of competition pressure. The conception of a stochastic frontier is widely used in modern researches of efficiencies; the model allows constructing a "best performance" frontier and estimating a relative efficiency score for each airport.

There are a sufficient number of researches devoted to estimation of efficiency levels of European airports on the base of frontier methods [5][6]. The most of researchers ascertain a relationship between airport's efficiency and characteristics of its organization structure like ownership, contacts with air carriers, managerial factors. The present paper innovates in this context by analysing the relationship between levels of a competition pressure and airport's efficiency scores.

2. Methodology

There are two main methodical points in this research:

- calculation of a level of the spatial competition pressure on airports, and
- calculation of airport's efficiency scores and their relation with the competition pressure.

The method of calculation of competition pressure is developed and described in details in this research, and efficiency scores are calculated on the base of a standard stochastic frontier model.

The level of the competition pressure: a calculation procedure

As it has been noticed in the introduction, a level of competition pressure can be considered as a proportion of population living in the overlapping regions to the whole population of airport's catchment areas.

A method to calculate this proportion using the information about population of each geographical "point" (a region 5x5 kilometres in our calculations), distances from this point to the nearest airports and available flights destinations and frequencies have been developed.

Let's consider a particular geographical place and a particular destination point required. The population of this place needs to choose one of the nearest airports for their trips. Let's have two characteristics for each airport:

- $Flights_{airport,\ time,\ destination}$ – a number of flights executed from a particular airport during a particular time interval to a selected destination. We will use this number as an indicator of "service availability", a frequency of flights to a selected destination. We assume that a law of diminishing returns is present here – each additional flight is more important if there are only a few flights a week than if there is a flight every hour already. To include this assumption into the calculation we use the logarithm of the number – $\ln(1+Flights_{airport,\ time,\ destination})$
- $Distance_{airport,point}$ – a distance from a particular place to a selected airport. A distance can be measured in kilometres or in travel times. In this research we use a distance in kilometres for

simplicity reasons. Usually the probability of a trip as a function of a distance to services is considered as sigma-shaped function (called distance decay function) (Fig.2). Some first kilometres don't make a difference, and after that we have a steep grade, and then kilometres don't make a big difference again. For this research we selected a log-logistic distance-decay function:

$$F(Distance) = \frac{1}{1 + \exp(a + b\ln(Distance))},$$

where $a = -11.13, b = 2.72$

Values of *a* and *b* parameter where selected following the [7] to reflect a travel time behaviour of people with a low value of time.

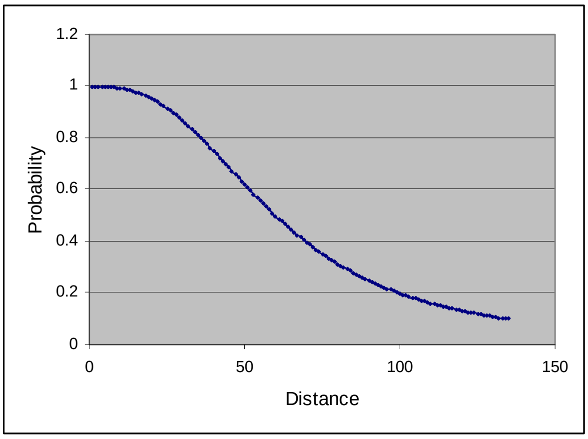


Figure 2. A distance decay function

The product of these two characteristics gives us a measurement of airport's availability for a particular point:

$$AirportAvailability_{airport,time,destination,pont} = \frac{\ln(1 + Flights_{airport,time,destination})}{1 + \exp(a + b\ln(Distance_{airport,point}))}.$$

Higher value of calculated AirportAvailability means better availability. If an airport doesn't provide flights to a selected destination, the AirportAvailability equals to 0.

Similarly we compute availabilities of all nearest airports, and after that calculate availability shares:

$$AirportShare_{airport,time,country,point} \frac{AirportAvailability_{airport,time,country,point}}{\sum\limits_{airport \in AREA} AirportAvailability_{airport,time,country,point}}.$$

The AREA, which includes the nearest airports, is defined for calculation reasons only. Theoretically, we can calculate values for all airports, but the assigned shares for airports located far from the geographical point will be negligibly small. In this research a circle area with the 300-kilometers radius to limit the AREA has been used.

The *AirportShare* value can be considered as a probability of a trip using a particular airport from a particular geographical point. If only one airport is available for this point – it will have AirportShare = 1.

On the base of this probability we can calculate a share of population of this point which will choose a particular airport as $Popul_{point}*AirportShare_{airport,time,direction,point}$.

After that this indicator for all geographical points and calculate the share of population which chooses a particular airport can be summarized.

$$AreaPop = \sum_{point \in AREA} Popul_{point}$$

$$CatchedPopulationShare_{airport,time,direction} = \frac{\sum_{point \in AREA} \left(Popul_{point} \cdot AirportShare_{airport,time,direction,point} \right)}{AreaPop}$$

Higher values of the CatchedPopulationShare mean less competition pressure for this direction for a particular airport. The 1 value means that the population has no choice and the nearest airport is a domestically natural monopoly [8].

The next point of the method to discuss is an importance of a particular direction. This point is highly related with a level of competition pressure, because it makes a difference if an airport is under high competition pressure for a very important direction or if the direction is a rare one and not important. For example, if we consider two airports, an international (flights to the domestic and other countries) and a national (flights inside the domestic country only), the competition for domestic flights is more important for the national airport and less important for the international one.

In this research we assume that the importance of the directions can be calculated as a share of flights to this direction from a selected airport:

$$DirectionImportance_{airport,time,direction} = \frac{Flights_{airport,time,direction}}{\sum_{direction=1}^{DIRECTIONS} Flights_{airport,time,direction}}.$$

After that we join competition pressure for passenger to all directions using the importance of directions as weights.

$$CompetitionPressure_{airport,time} = \sum_{direction=1}^{DIRECTIONS} \begin{pmatrix} DirectionImportance_{airport,time,direction} \cdot \\ \cdot \left(1 - CatchedPopulationShare_{airport,time,direction}\right) \end{pmatrix}.$$

So we constructed a metric of the competition pressure on an airport based on its spatial position. The metric also uses number of flights to different directions, and that’s why it can vary over time. The metric doesn’t utilize a quality of airport’s services like check-in queuing, registration facilities, parking spaces, etc.

The suggested method has some limitations:

1. An economic activity level in the geographical point is not included into consideration. Without this correction we assume the uniform distribution of businesses and other features which can have an influence on airport necessity. Usually the businesses are concentrated around an airport (or an airport is constructed near to country business centres), so the calculated values of competition pressure will be overestimated. The method can be improved by using a product of population and an index of economic activity in region instead of the $Popul_{point}$ variable.
2. An importance of directions for an airport is calculated on the base of a share of flights to this direction. In practice an airport can have higher profit margins for some relatively rare directions, and can consider them as more important.
3. As it is mentioned in the introduction, the direction can be interchangeable, that’s why the competition pressure can be underestimated. The correct way is to use a metric of interchangeability between each pair directions (based, for example, on a distance between them). In this research the destination countries instead of direction themselves, which is an equivalent of an interchangeability metric, which is 0 for different countries (no interchangeability) and 1 for the same country (an absolute interchangeability) are used.

Stochastic Frontier Model

For estimating airports’ efficiency levels a stochastic frontier model has been applied. The model can be formalised as:

$$y = f(x, \beta) + \varepsilon,$$
$$\varepsilon = v - u, v \sim N(0, \sigma_v^2), u \geq 0,$$

where

y – an output;
x – a vector of resources/inputs;
f – a production/cost function;
β – a vector of unknown coefficients;
ε – a composite error term.

The first component of composite error term, v, shows the random variation of the efficiency frontier, and the second one, u, shows the technical inefficiency of airports. The individual efficiency of the airport i can be estimated as [9]:

$$TE_i = e^{-E(u_i|\varepsilon_i)},$$

where $E(u_i|\varepsilon_i)$ – conditional expectation of u_i given estimated ε_i.

For estimating unknown parameters of the model we need to make some assumptions about distributions of error terms and a functional form of the production function. The usual assumption in the stochastic frontier model is the normal distribution of the random component v_i with zero mean. The truncated normal distribution for the second error term component u_i with a conditional mean has been used (the first distribution parameter depends on the set of factors z, the most important of which is a level of the competition pressure):

$$u_i \sim N^+(\delta_0 + \sum_{i=1}^{m} \delta_i z_{it}, \sigma_u^2) .$$

A Cobb-Douglass function with time parameters as a functional form of the frontier is considered:

$$\ln(y_{it}) = \beta_0 + \sum_{i=1}^{k} \beta_i \ln(x_{it}) + \sum_{i=1}^{k} \tau_i \ln(x_{it}) \cdot t + \nu_i - u_i .$$

3. Data

The data set includes characteristics of European airports' activities from 2003 to 2007 (data for 2008 is not filled enough for this moment) and airports' geographical locations. A world population grid for calculation of a level of competition pressure has been used.

There are four main data sources used:

1. The Eurostat (the Statistical Office of the European Communities) database is a source of information about airport activities. The information about each airport includes:
   a) a number of passengers carried. All passengers on a particular flight counted once only and not repeatedly on each individual stage of that flight; direct transit passengers are excluded. This indicator is used as the main output of airport's activity. Using the value without transit passengers allows reducing specifics of hub airports and should be related with competition for passengers more closely;
   b) a number of direct flights by country. Eurostat provides information about a number of flights to European countries, and also flights outside the European Union. The information is used for calculations of airport's flights to destination frequencies, and also for computing airport's destination importance.
   c) a number of employees of airports. Only employees hired directly in airports are included; we keep out all other organizations located on a site of an airport.
   d) airports' infrastructure. We collected the information about a number of check-in facilities, gates, runways, and parking spaces as input resources of airports' activity.
2. The Atlas of Airports for 2005 from the Ruimtelijk Planbureau, Netherlands, is also used as a source of airport information as an addition to the Eurostat database.
3. The Gridded Population of the World database from the Centre for International Earth Science Information Network (CIESIN) includes population counts in 2005, adjusted to match UN totals. The raster data contains information about Europe population with 2.5 arc-minutes (~5 kilometres) resolution.
4. Digital Aeronautical Flight Information File (DAFIF) database is a complete database of up-to-date aeronautical data, including information on airports. The database is used together with the Google Earth software as a source of European airports geographical coordinates.

4. Stochastic Frontier Model Specification

Specification of the stochastic frontier model requires three groups of indicators – airport outputs, airport inputs and airport or external indicators related with airports' efficiency levels.

There are two main outputs of an airport – passengers carried and mail/cargo loaded/unloaded. As the relationship between a level of efficiency and competition for passengers is studied, the passengers as the main output of the airport have been used. So in this research we use the term "airport's efficiency level" as "airport's passenger carriage efficiency level". It has been done to make the model simpler, because spatial competitions for passengers and for cargo are significantly different things. The simplification will lead to lower levels of passenger service efficiency for airports oriented to cargo carriage. a number of passengers carried (*PassengersCarried*) as an output has been selected, although some researches used a number of flights executed, a potential number of passengers seats carried for the same purposes. A number of passengers carried is an indicator of actual airport's economic output, when other indicators are related with potential output which is possibly not fully utilised by the public.

We considered a number of airport infrastructure and labour resources as model inputs. Numbers of check-ins (*CheckIns*), gates (*Gates*), runways (*Runways*), parking spaces (*ParkingSpaces*), and a number of employees (*Employees*) were initially included into the model, but high level of correlation between inputs led to multicolleniarity problems. A decision to exclude number of check-ins and gates due to high correlation with a number of runways is made. Another explanation of the exclusion can be formulated in terms of resource manageability. Numbers of gates and, especially, check-ins are more flexible and manageable, than a location and a number of runways, so it can be considered not as resources, but as management efficiency components.

The final model component is parameters related with airport's efficiency. As the main goal of this research is to investigate the relationship between airport's efficiency and the level of the competition pressure, we used only one parameter (*CompetitionPressure*) calculated by formulas presented in the Methodology section.

As a functional form of the production function we initially chose the Cobb-Douglass function with time components. Time components included to reflect changes of the production frontier during the selected time interval (from 2003 to 2007). Usually changes of the frontier form are related with some innovations in the production process, and it is possibly that there are no significant changes during this short time interval. To test this hypothesis we used the likelihood ratio test, and the observed value is as follows:

$$\chi^2_{obs}(r) = 2\left(Ln(H_1) - Ln(H_0)\right) = 2\left(-252.698 - (-253.384)\right) = 1.372,$$

where

Ln(H₁) – log-likelihood function value for the model with time components,

Ln(H₀) – log-likelihood function value for the model without time components,

r=3 – a number of time components (restrictions).

So we rejected a hypothesis about a significant advantage of the model with time components, and used the model without time components in our research.

The final stochastic frontier model is as follows:

$$\ln\left(Passengers\ Carried_{it}\right) = \beta_0 + \beta_1 \ln\left(Runways_{it}\right) + \beta_2 \ln\left(ParkingSpaces_{it}\right) + \\ + \beta_3 \ln\left(Employees_{it}\right) + v_{it} - u_{it},$$

$$u_{it} \sim N^+\left(\delta_0 + \delta_1 CompetitionPressure_{it}, \sigma_u^2\right),\ v_{it} \sim N\left(0, \sigma_v^2\right)$$

5. Results

Using the formulas presented in the Methodology section the levels of competition pressure for all airports in the sample for each time point are calculated. Results for selected airports are presented in the Table 1.

Literally the level of competition pressure shows the part of the population of airport's catchment area who can choose other airports for their trips on the base of distances to airports and flights frequencies. For example, a value for London Heathrow for 2007 is 0.917 that means that 91.7% of people living in 300 kilometres from the airport will choose other airports (London Gatwick) for their travel if they take into account distances and flights availability, but don't consider other airports' features. Another example is Riga International Airport, 67.0% of population of which potential catchment area will choose another airport (and other 33.0% will choose Riga airport).

Higher (closer to 1) values of the indicator means higher competition pressure (1 means that 100% of people have alternatives with better characteristics of distance and flights availability), lower values means lower level (0 mean that the whole population of the catchment area have no choice and should use the selected airport). The first margin is unreachable in the real situation; the second is a usual position for islands with one airport only.

The average value of the indicator equals to 0.872 and shows that the overall competition pressure is high for European airports.

Another observation is the increasing of the competition pressure level for many airports during the time interval, which is related with the growth of an available number of flights/directions.

Table 1. Levels of competition pressure of some European airports

ICAO Code	Airport Name	Average number of passengers carried, mln.	Level of competition pressure				
			2003	2004	2005	2006	2007
EGLL	London Heathrow	66.68	0.905	0.909	0.912	0.915	0.917
LFPG	Paris-Charles De Gaulle	54.81	0.875	0.871	0.879	0.885	0.886
EDDF	Frankfurt/Main	51.66	0.918	0.932	0.933	0.934	0.935
EHAM	Amsterdam/Schiphol	44.01	0.923	0.932	0.935	0.941	0.943
LEMD	Madrid/Barajas	43.65	0.589	0.597	0.597	0.601	0.602
EGKK	London Gatwick	32.90	0.918	0.919	0.922	0.923	0.925
EDDM	Munchen	29.64	0.913	0.919	0.919	0.919	0.918
LIRF	Roma/Fiumicino	28.35	0.846	0.863	0.862	0.864	0.866
LEBL	Barcelona	27.81	0.778	0.784	0.786	0.790	0.793
LFPO	Paris/Orly	24.93	0.887	0.877	0.886	0.892	0.887
EPWA	Warszawa/Okecie	7.63				0.646	0.659
EVRA	Riga International Airport	2.45			0.669	0.669	0.670
EETN	Tallinn/Ulemiste	1.49	0.607	0.721	0.715	0.716	0.708
EYVI	Vilnius	1.23			0.451	0.458	0.459

Next we grouped airports' levels of competition pressure by country. The Table 2 contains values of competition pressure for European countries. There are not used any weights for grouping airports, but are included airports with more than 1 million passengers carried only into the grouping in the present research.

For many European countries there are just 1-2 main airports, which service the lion's share of population and have competition pressure from airport in neighbour countries only.

Table 2. Levels of competition pressure by countries

Country	Airports (with more than 1 mln. passengers)	Average Level of Competition Pressure		Country	Airports (with more than 1 mln. passengers)	Average Level of Competition Pressure
Austria	2	0.892		Lithuania	1	0.456
Belgium	2	0.942		Luxemburg	1	0.965
Bulgaria	3	0.653		Malta	1	0.747
Cyprus	2	0.452		Netherlands	3	0.947
Czech Republic	1	0.874		Norway	7	0.877
Denmark	2	0.901		Poland	5	0.784
Estonia	1	0.713		Portugal	5	0.714
Finland	1	0.652		Romania	1	0.602
France	18	0.929		Slovakia	1	0.893
Germany	19	0.936		Slovenia	1	0.899
Greece	8	0.834		Spain	26	0.826
Hungary	1	0.650		Sweden	5	0.833
Ireland	3	0.882		Switzerland	3	0.938
Italy	21	0.878		United Kingdom	23	0.940
Latvia	1	0.670				

Another main result of this research is construction of airport's catchment areas with the following improvements:

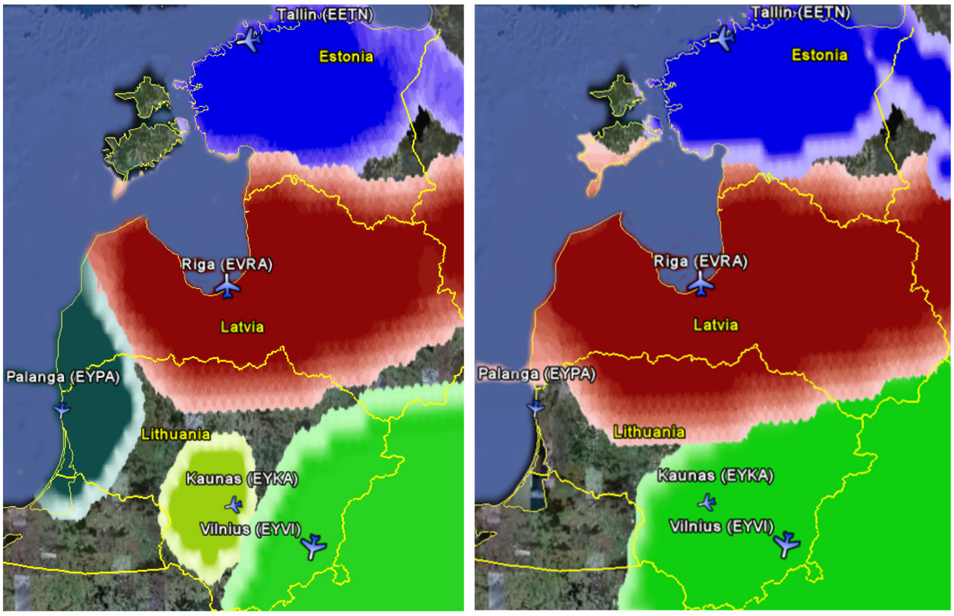
1. Airport's catchment area should be built with information about the nearest airports and their flights availability.
2. Airport's catchment area can vary for different destinations.

The example of the first improvement is presented on Figure 3.A, catchment areas for airports in Estonia, Latvia, and Lithuania for flights to Germany. The catchment area of the Vilnius airport is restricted by flights provided by Kaunas and Palanga airports, when the catchment area of the Riga airport is not restricted by other domestic airports.

If we compare catchment areas for flights to Germany (Fig. 3A) and to Austria (Fig. 3B) we can see the second improvement – the difference is significant. As Kaunas and Palanga airports don't provide (in 2007) a significant number of flights to Austria, the Riga and Vilnius airports have captured their catchment areas for this direction.

One of shortcoming of the method (and a direction for future researches) is a catchment of passengers from outside the European Union (Russia and Byelorussia for considered Baltic countries). Actually Riga, Vilnius, Tallinn airports also catch passengers from Russia, so the calculated catchment area and relatively a level of competition pressure is less than it is in reality. Additional statistics can be used to improve this shortcoming.

We also placed international borders on Figure 3. Some researches uses them as borders of catchment areas, but there is no material reasons to use them for this purposes. Cultural reasons (like languages, for example) are still play the roles, as well as habits of people.



A B

Figure 3. The Catchment Areas of Baltic Airports (A – flights to Germany, B - flights to Austria)

The next step of the research is estimating the parameters of the stochastic frontier model. The model allows ascertaining the possible relationship between a level of competition pressure and airport's efficiency.

Usually the maximum likelihood method is used to estimate the stochastic frontier model. A well-known problem for the model is high outlier sensitivity. In this research we selected a Cobb-Douglass function which is not flexible enough, and the problem's consequences can be arisen. To reduce the problem of the jack-knife bootstrapping procedure for estimation standard errors of coefficients has been used. We run two different versions of the jack-knife procedure:

- with excluding a particular airport-time observation, and
- with excluding all observations for an airport.

Both procedures give the similar results, so the first one for further analysis has been selected. The estimates are presented in the Table 3.

Table 3. Stochastic frontier model estimation results

	Coefficients	Jack-knife Std. Err.	P-value	90% conf. interval	
Dependent variable					
ln(PassengersCarried)					
Frontier					
ln(Runways)	1.131	0.089	0.000	0.985	1.277
ln(ParkingSpaces)	0.070	0.036	0.053	0.011	0.129
ln(Employees)	0.365	0.049	0.000	0.285	0.446
Constant	12.670	0.298	0.000	12.178	13.161
Inefficiency					
CompetitionPressure	**-0.962**	**0.557**	**0.085**	**-1.882**	**-0.042**
Constant	1.241	0.552	0.025	0.330	2.152
Sigma_u2	0.285				
Sigma_v2	0.218				
Gamma	0.567				
Log likelihood	-253.384				

We don't pay special attention in the article to the form of the stochastic frontier (just say that signs of all estimates are expected). The main attention has been oriented on the coefficient for the *CompetitionPressure* indicator (in bold in the Table 3).

The value (-0.982) is significant; the negative sign shows that higher values of *CompetitionPressure* lead to lower values of airport's inefficiency, and, obviously, higher values of airport's efficiency. So we ascertain the positive relationship between the level of competition pressure and airport's efficiency, which match our expectations based on the economic theory.

One of advantages of the stochastic frontier model is a possibility to calculate individual values of efficiency. Efficiency values of some selected airports are presented in the Table 4 (please note that the values show the efficiency of passenger carriage as described before).

Table 4. Estimated efficiency levels of European airports

ICAO Code	Airport Name	Country	Efficiency
LEMG	Malaga	Spain	83.3%
EGLL	London Heathrow	UK	78.9%
EGKK	London Gatwick	UK	78.8%
LPFR	Faro	Portugal	76.3%
EKCH	Kobenhavn/Kastrup	Denmark	75.2%
EDDS	Stuttgart	Germany	75.0%
LGIR	Irakleion	Greece	74.7%
EDDM	Munchen	Germany	72.4%
ENGM	Oslo/Gardermoen	Norway	71.7%
LEZL	Sevilla	Spain	71.5%
LFPG	Paris-Charles De Gaulle	France	69.8%
EBBR	Bruxelles/National	Belgium	64.9%
EDDF	Frankfurt/Main	Germany	64.7%
EVRA	Riga International Airport	Latvia	47.3%
EETN	Tallinn/Ulemiste	Estonia	45.2%
EYVI	Vilnius	Lithuania	34.7%
	Minimum		*24.1%*
	Maximum		*83.9%*
	Mean		*57.9%*

6. Conclusions

In this research we presented a new definition of airport's catchment area. The proposed definition is based on the competition ground, instead of classical direct distance or transit time measures. All possible airport alternatives (for a particular direction) for population of a geographical point to calculate a share of population potentially captured by an airport have been considered. Similar calculations for each geographical point give us airport's catchment area. The competition base of our approach reflects the real situation more closely – a person has to spend a significant time for trip to an airport and should be included into airport's catchment area if he has no other alternatives. Another improvement is a construction of different catchment areas for different destination points.

The next innovation of the research is the calculation procedure for the level of the competition pressure. Formulas based on the new catchment area definition and the concept of overlapping catchment areas has been suggested.

In the practical part of the research the catchment areas for European airports and levels of the competition pressure are calculated. Some examples of calculations are presented as tables and figures in the research, but all results are omitted due to space limitations.

The main goal of the research is the investigating of relationship between the level of the competition pressure and airport's efficiency level. The stochastic frontier model for estimating efficiency levels are used and the statistically significant positive relationship between the indicators has been found.

Finally we can note that the methods developed and suggested in this article have a high application area and could be useful for the researchers of airport's competition and efficiency.

References

1. *Regional and Small Airports Study*. *Non-financial Analysis*, Transport Canada, 2008.
2. Starkie, D. *Aviation Markets: Studies in Competition and Regulatory Reform*. Farnham: Ashgate Publishing, 2008. 246 p.
3. Strobach, D. Competition among airports and overlapping catchment areas – an application to the state of Baden-Wurttemberg, *Competition in the European Airport Industry, German Aviation Research Seminar Series*, No 4, 2008. 27 p.
4. Kumbhakar, S.C. and Lovell, C.A.K. *Stochastic Frontier Analysis*. Cambridge: Cambridge University Press, 2003. 333 p.
5. Pels, E., Nijkamp, P., Rietveld, P. Access to and competition between airports: a case study for the San Francisco Bay area, *Transportation Research, Part AL Policy and Practice,* Vol. 37, No 1, 2003, pp. 71-83.
6. Barros, C.P., Marques, R.C. *Performance of European Airports: Regulation, Ownership and Managerial Efficiency: Working Paper Series,* Technical University of Lisbon, 2008, p. 31.
7. Geurts, K.T., Ritsema van Eck, J.T. *Accessibility Measures: review and applications, RIVM Report 408505 006.* Utrecht University, 2001, p. 147.
8. Forsyth, P. Airport Competition: Regulatory Issues and Policy Implications. In: *Competition Policy and Antitrust/D. Lee.* England: Emerald Group Publishing, 2006, pp. 347-369.
9. Johdrow, J., Lovell, C.A.K., Materov, I.S., Schmidt, P. On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model, *Journal of Econometrics*, No 19, 1982, pp. 233-238.

Transport and Telecommunication, 2009, Volume 10, No 4, 18–27
Transport and Telecommunication Institute, Lomonosova 1, Riga, LV-1019, Latvia

USING T.SAATY METHOD IN TRANSPORT SYSTEMS PLANNING

Viktors Siperkovskis

Transport and Telecommunication Institute
Lomonosova Str.1, LV-1019, Latvia
Ph.: +371 29234603. E-mail: viktors.siperkovskis@tsi.lv

A transport system of a country meets the needs of individuals and enterprises located in its territory in transportation and related services. On the one hand it depends on the level of the development of state economy; on the other hand the transport system's development itself influences the GDP of the specific regions and the whole country. Transport system's development planning requires the systematic approach and the use of the indicators, which take into account its influence on the society's welfare. The pairwise comparison method introduced by Thomas L. Saaty meets the requirement of the systematic approach. The procedure of the analytic hierarchy process used in this method allows a group of people to co-operate on the particular problem, to modify the individual judgments and as a result to combine the group judgments according to the basic criterion. Two objectives are followed when working on the given subject: the demonstration of the opportunity of analytic hierarchy process' (AHP) use in estimation of the transport systems' investment influence on the Latvian society's welfare and assessing the opportunity of implementation of AHP algorithm using a standard Microsoft Office package and applying it to 5-6 level hierarchies and matrices that have up to 15 columns and lines.

Keywords: transport system, decision support methods, analytic hierarchy process, analytical planning

1. Introduction

A complex of different transport types and a transport network form the integrated transport system of a state. The transport system can have one owner – the state, but it can also have many owners (including the state), which is more common in the modern world practice. It is obvious that the more owners the system has, the more difficult is to carry out its consistent development measures and the more important is the state's role in coordination of well-balanced infrastructure and different types of transport development in public interest.

According to the Statistical classification of economic activities [1] the transport belongs to the category of service industries. The service [2] has four distinguishing features: intangibility, inseparability from a source, quality changeability and perishability. Hence it appears that transport entrepreneurial activities fully depend on the transportation needs of residents and non-residents operating in other industries (processing industry, construction, trade industry etc). At the same time, there are some research works [3], [4], [5] which strongly indicate that the transport infrastructure's maturity considerably influences the economic development of specific regions and even countries. It is obvious that the transport industry's development requires the systematic approach, where the state planning objects would not only be the transport network (infrastructure) and transport enterprises with the state share, but the entire state transport system, taking into consideration the influence of this system's development on the society's welfare.

That decision-making support methods used when planning considerably depends on the problem model [6]. There are *objective* and *subjective* problem models. The meaning of the objective model doesn't depend on the opinion and preference of the decision-maker (decision-maker, individual or collective management body) whose duty is only to raise a problem. The decision-making methods provided that the objective model is used are developed in the frame of *operation research*. If the model is correctly developed, its nature doesn't depend on its developer or user. However, the transport system model development even for such a small state like Latvia is obstructed by the need of using the variety of mutual dependent criteria and the lack of opportunity of getting its statistically significant changes.

The subjective model is usually developed with the help of experts and reflects the decision-maker's problem perception, his priorities and aims. Herewith the multi-objective methods of decision-making support can be used, as well as the methods of alternative target valuation. All the models of big transport systems are subjective.

For example, the construction of the gas-pipe "Blue Stream" on the bottom of the Baltic Sea reflects the priorities and aims of Russian and German leaders: ignoring the project' great cost, they exclude the gas supply risks to Europe in case of conflicts with the transit countries and provide their national gas-transporting companies with the guaranteed amount of work for several decades. Regardless the discriminating project nature towards the non-German business, the most of EU countries supports this idea because they can rely on the stable gas supply for their enterprises and population after the project's realization. The real policy, international economic relations and national business environment are the subject of mutual compromise and consensus achievement.

The possibility of respecting the interests of the parties concerned and achieving the consensus regarding the main aim (focus) is taken as a basis of the pairwise comparison method introduced by Thomas L. Saaty [7]; the method can be used for the expert estimations of the future logistic flows, the priority projects' selection and transport systems' development planning. The method corresponds to the consistency principle; the procedure of the analytic hierarchy process used in this method allows a group of people to co-operate on the particular problem, to modify the individual judgments and as a result to combine the group judgments according to the basic criterion.

Two objectives were followed when working on the given subject: the demonstration of the opportunity of analytic hierarchy process' (AHP) use in estimation of the transport systems' investment influence on the Latvian society's welfare and assessing the opportunity of implementation of AHP algorithm using a standard Microsoft Office package and applying it to 5-6 level hierarchies and matrices that have up to 15 columns and lines.

2. Prevailing Practice of Transport System's Development Planning in Latvia

According to the regalement of the Cabinet of the Republic of Latvia, the document "Conceptual Issues of Transport Development" is developed for every seven-year period (according to the EU financial planning period); it is a political planning document, indicating the main transport policy's principles, the aims and the priorities of transport industry development. The current document [8] sets the following general aim of the industry development for the period 2007-2013: "quality and competitive, integrated into the Eurasian transport system infrastructure, business environment, secure communication, and quality and available to all transit, logistics and public transport services". Then the targeted control indicators are listed (to renovate N km of the roads, to modernize the ports' waterworks being in the critical state, etc). It is obvious that the main mission of the "Conceptual issues of transport development" is to motivate the long-term financing of transport system renovation and modernization. Generally, the preparation of such documents is carried out by the specialists of the ministries in cooperation with the project, construction and agency companies interested in tapping the state and European resources.

The practice of development planning of the system in general is not the most popular; more common is the planning of its single elements, for example the development of Riga International Airport or Riga Seaport. Each object has its engineering project, the research on its environmental effect, the calculation of the amount and sources of required financing, the estimation of the economical effect after its realization. The total required amount of financing is calculated as a sum of all projects' financing. However the state "profit" of the projects' realization does not always equal to the arithmetical sum of each single project's "profits'. The transport system transformation can produce an effect of "superposition" of transport flows and its elimination will require the additional investments.

If any long-term transport system plans or project exist, then they are available only in the Ministry of Transport and they are not publicly accessible. It is possible to study the long-term development strategy project «Latvija-2030» instead, which is released on the official site of the Ministry of Regional Development and Local Government.

This poetically drafted document devotes to Latvia the role of "gate" in the Baltic Sea shores at the crossroad of the flows between the West-the East and the North-the South. Furthermore the authors of the document absolutely ignore the competition between the Latvian transport companies from one side and the Lithuanian, Estonian and Finnish companies from another side for the opportunity to serve the cargo traffic of the Russian and other Eastern exporters and importers. The fact that the Russian Government has confirmed the transport system's enlargement and modernization programs [9] and carries out the large-scale works (especially in the North-Western region close to the Baltic Sea) in order to maximize the amount of jobs and increase in the gross product thanks to the transportation and handling of goods is not taken into consideration.

The real situation is the following: in the context of the instable demand the Latvian transport system must have the power and capacity margin; the businessmen must gain the clients' trust and have material and technical base sufficient for meeting the expectable needs in transport and related services.

Hence the transport system's target activities must be based on the loyalty estimation of potential clients and the forecast of their transportation needs; the activities must take into consideration the specifics of the state development (bureaucracy, corruption, political lobbying) and economic dependence on the policy of the foreign investors present in Latvia and international financial institutions.

If to follow the position that the greater the state GDP per capita the better is for the society, then the transport system development task is to get as greater GDP input as possible from the use of the system. Logically, the efficiency of state investment into the transport system must be valuated by the GDP increase. Theoretically the valuation of state "profit" from these investments is possible, but only with the help of indirect methods (creation of new jobs, additional taxes and fees of transport companies, the "added value" of the companies selling goods and services to the transport industry); the direct GDP input valuation is not possible. Generally the state invests into the transport infrastructure, but mainly private companies gain a profit from its use.

The argument of considerable GDP input is a popular method; it was often used by the management of Latvian Ministry of Transport and the management of various Latvian professional associations (transit business, shipment by car etc) for the purpose of pointing out the transit importance for the Latvian economy. Nevertheless, the other indicators are used in industry's development planning.

3. Algorithmic introduction of Saaty's Analytic Hierarchy Process method

The method is primarily deployed to support the decision-making process by hierarchical composition and rating of the alternative decision options. For detailed presentation of the mathematical foundations, procedures and examples of application of the method one is recommended to consult the works of Thomas L. Saaty [7], [10]. Herewith just the stages and explanation that are necessary for understanding the calculations presented.

In order to solve a problem using the analytic hierarchy process one should formulate the question, identify the criteria or factors that affect the research question and build a hierarchy. Depending on research objectives the forward process hierarchy can be composed, which provides the description of environment, where the system operates, and possible estimations (look-ahead scenarios, a measure of influence, utility) and also the return hierarchy. The latter begins where designed process comes to an end. The backward process hierarchy is applied as the declarative mechanism for definition of those courses of action, which the system should follow in order to achieve the "expected" outcome of the scenario. All elements of the hierarchy have to be properly defined in order to exclude uncertainty. The author combined Table 1 illustrates the recommended [10] levels of the forward and backward processes.

After hierarchical or network representation of the general problem is complete, each alternative is examined and the most important of these is selected. The hierarchy is considered completed when each element of the set level functions as criterion for all elements of subordinate level. Otherwise the hierarchy is considered incomplete, and for the definition of scales of the corresponding elements, the hierarchy can be divided on sub-hierarchies, which have the uppermost element as a generic element.

Table 1. Illustration of key elements of the forward and backward hierarchal processes

FORWARD PROCESS HIERARCHY	Hierarchy levels		BACKWARD PROCESS HIERARCHY
Objective	I	I	The future expected by one of actors or one of the possible outcomes of forward process
		II	One or several expected scenarios which he wishes to implement
Various forces which influence an outcome	II	III	The list of problems or situations which can prevent the implementation of scenarios
Actors who manipulate with forces	III	IV	Actors who can affect the problem solutions
The objectives of actors	IV	V	The objectives of actors
The policy of actors*, which they follow for realization of their objectives	V	VI	The policy of actors*, which they follow for realization of their objectives
Scenarios (outcomes) for which each actor stands, as a result of realization of their objectives (and applying of policy)	VI	VII	Policy (or modifications of objectives) of the separate actor, which can influence the implementation of expected future conditions if to follow them

**Comment*: The level of *The policy of actors* is optional, it can be missing

The judgment on importance is performed for actions or the object standing in the left column, towards the action or the object standing in the top line. Here, if $a_{ij}=\alpha$, then $a_{ji}=1/\alpha$, $\alpha\neq 0$. If $a_{ij}=a_{ji}$, then $a_{ij}=1$ and $a_{ji}=1$; in particular $a_{ii}=1$ for all i. In this case the matrix A is valid:

$$A=\begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ 1/a_{12} & 1 & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ 1/a_{1n} & 1/a_{2n} & \dots & 1 \end{bmatrix} \qquad (1)$$

and it is a positive antisymmetric irreducible matrix. For the formation of matrix the expert presents $n(n - 1)/2$ judgments (n- a degree of pairwise comparison matrix). For each level of hierarchy, the number of such matrices is equal to the number of coherences between the elements of this level with the elements of higher level; and the judgments over the importance of the lower level elements from the position of the higher level element are presented in each pairwise comparison matrix.

Saaty has introduced a scale of importance (from 1 to 9) for the measurement of superiority degree of one element of hierarchy over the other. Measurement of importance is carried out as follows: pairwise comparison is *same important* – 1, one element is *weekly more important* than another – 3, *moderately more important* – 5, *strongly more important* – 7, *absolutely more important* – 9; and in a compromise solutions' situation, intermediate values (2, 4, 6) are used.

The following step is a calculation of a priority vector (W) for each pairwise comparison matrix. In mathematical terms it is a calculation of main eigenvector, which turns into a priority vector after normalization (a column-vector of relative weights of alternatives). The most mathematically proved way is the method of raising the matrix in greater degrees and division of each raw by the total sum of matrix elements [6], but this method requires lengthy calculations (calculation of matrix's latent roots from the system of homogeneous linear equations relevant to characteristic equation matrix). The approximate value of eigenvector can be found as calculation of geometrical mean $\overline{a}_{ijG}$ for each matrix raw with the following normalization of obtained column-vector gives the most exact result.

The consistency of judgments should be followed when making the changes. In general, the consistency means that given the main amount of raw data, all the other necessary data can be logically received from the amount. The valuation of consistency of matrix local priorities is determined with the maximum latent root of matrix judgments λ_{max}. It is common knowledge that the consistency of positive antisymmetric matrix is equivalent to the equality requirement of its maximum latent root λ_{max} c n. The closer λ_{max} is to the judgments' matrix dimension (n), the more consistent is the result (the consistency of experts' judgments). For determining the maximum latent root it is required to carry out the following actions: to sum the judgments' results for each column (b_i), to get a column-vector B as a result, to multiply the column-vector B by the priority vector W.

$$\lambda_{\max} = B \cdot W\,. \qquad (2)$$

Hence, the eigenvector provides priorities' ordering, and the latent root is a measure of judgments' consistency. Deviation from consistency can be formulated by the value of consistency index (CI):

$$CI = (\lambda_{\max} - n)/(n-1)\,, \qquad (3)$$

where n is matrix dimension.
When consistency is ideal, *CI*= 0 (as λ_{max}=n). For the valuation of consistency degree's sufficiency, Saaty suggests to use the consistency ratio (CR), which equals:

$$CR = CI / CIS\,, \qquad (4)$$

where *CIS* is the mean of CR, calculated for the large amount of randomly generated antisymmetric pairwise comparison matrices in the scale of importance presented above. The value of CIS is presented in Table 2 according to [7].

Table 2. The average value of the Consistency Index for n- level matrices

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CIS	0	0	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49	1,51	1,48	1,56	1,57	1,59

It is recommended to consider the result vector of relative weight to be acceptable, when CR is about 0,10 (but doesn't exceed 0,20). For n=3 CR must not exceed 0,05, and for n=4 the limit is 0,08. The pairwise comparison matrix inconsistency can be caused by the expert's personal skills or the degree of uncertainty of appraisal object and it is a result of these factors' interaction. In case when consistency relation exceeds the recommended limit, it is recommended to revise the judgments.

We follow the synthesis principle when finding the generalized weight (global priorities) of given alternative solutions. The priorities are being synthesized starting from the second level down. For this purpose for each hierarchy level we build the generalized comparison matrix W_{Hi} with dimension of $n \times m$, where n is a number of rows, which corresponds to the number of elements of the hierarchy level, and m is a number of columns, which corresponds to the number of elements of the above hierarchy level. The matrix elements $n \times m$ are the column-vectors of priorities of the relevant hierarchy level. For derivation of the global priorities sequentially we multiply the generalized priority matrices starting from the second level. As a result we get the column-vector R, whose elements characterize the global priorities of alternative (projects, estimations etc) or, what is just he same, their significance for the highest hierarchy level.

$$R = \prod_{i=1}^{n} W_{Hi} \ . \tag{5}$$

The calculation algorithms of the forward and backward processes is the same, however there are particularities in construction of the hierarchies.

4. Using AHP for Analysis and Planning

Two related hypothetical tasks have been solved in order to demonstrate capabilities of AHP:

1) If the World Bank will supply the government of Latvia will all the necessary resources for the transport infrastructure development with a condition that it would increase the society welfare, and then what would be the possible priority projects?
2) What strategies or policies may be used by the individual stakeholders and organizations to complete the priority project?

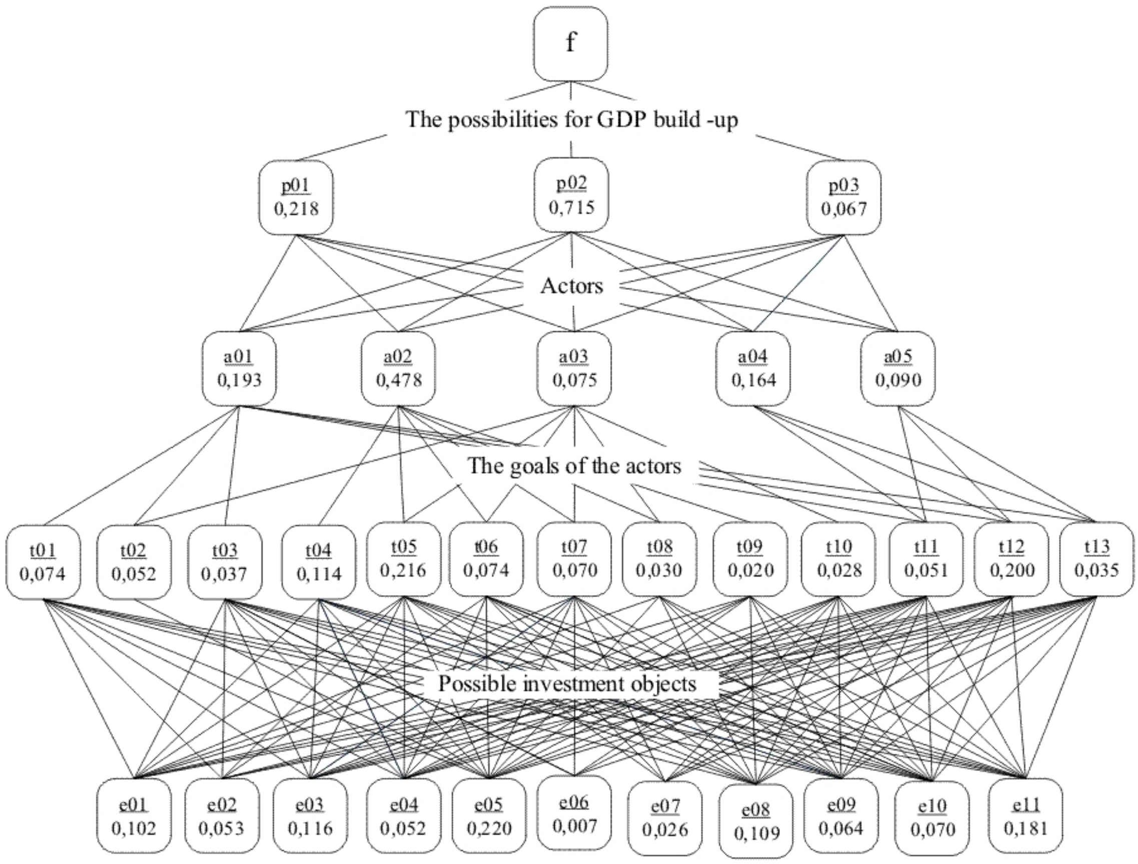
The list of eleven scenarios is composed on a basis of transport infrastructure elements mentioned in mass media. The frequency of mentioning is not taken into account.

The task of selecting the most feasible financing scenarios is depicted as a direct process hierarchy (Figure 1), whereas the goal is the growth of GDP initiated by the transport infrastructure development. The industry sector's ability to influence the GDP depends on volume of the purchased goods and services from the non-transport entities, which is reflected in the second hierarchy level. Third level includes the actors who may significantly influence the realization of the possibilities. The fourth level indicates their goals. The lowest, the fifth level of the hierarchy is represented by the projects that need to be graded.

This developed hierarchy reflects the actual decision-making process. The choice of financing particular projects may never be a democratic process. According to the Arrow's impossibility theorem [12], during any procedure of voting there will be a process participant, whose preference will be in absolute agreement with the final selection. Obviously, the decision about assigning resources will rely on actors' goals and their significance.

Twenty two pair comparison matrices were developed to rank the possible scenarios of financing: level II - one of 3 by 3 size matrix, level III - three of 5 by 5 size matrices, level IV - five of 13 by 13 size matrices, and level V – thirteen of 11 by 11 size matrices. Saaty's nine-point relations scale was used for comparisons, while the role of experts was fulfilled by the author and the MBA students. Perceptions with regards of the projects significance were recorded in a specially developed universal template. It is an MS Excel worksheet where one may record a reverse symmetric matrix of the pair comparison with the maximal size of 15 by 15, calculate the vector of priorities and verify the consensus of experts' estimations. Figure 2 illustrates the fragment of the MS Excel spreadsheet for one of the matrices of the third-level hierarchy (Figure 1).

Perceptions about actors' a01...a05 significance with regard to the upper standing element of the hierarchy p01 are recorded in the cells B7:F11 of the electronic spreadsheet. This is the actual matrix of pair comparison. The numbers have to be filled above the main diagonal line. For example, while entering the value "1/4" in the cell C7, the cell B8 will automatically display the value "4", (quotient 1:1/4).



I. The overall goal (focus) – improvement of the society welfare.
II. *The possibilities for GDP build-up*: p01- selling transportation services to the residents, p03- to the non-residents, p02- selling goods and services to the transport organizations and their personnel.
III. *Actors*: a01- international financial and political organizations, a02- Latvian political parties and their sponsors, a03- industry professionals (experts, developers, etc.), a04- non-residents, who initiates international transport movements (transit ordering parties), a05- residents who generate and receive flows of cargo.
IV. *The goals of the actors*: t01- receiving profits from the investments into the Latvian economy, t02- timely returns on the investments, t03- likelihood of the economical influence on the government, t04- financing political parties, t05- receiving illegal profits, t06- attracting foreign investments, t07- creating environment for the entrepreneurship development, t08- minimizing the negative impact on ecology, t09- providing the population with all necessary transportation communications, t10- securing the employment and stable income, t11- decrease of the exploitive expenses related to the usage of the advanced infrastructure, t12- reasonable prices at the high level of service, t13- reliability.
V. *Possible investment objects*: e01- the infrastructure of the Latvian railways, e02- mobile unit of the Latvian railways, e03-national highways, e04- municipal motor roads, e05- international toll highway (M9, project EU- Russia), e06- customs service stations on the east EU border, e07- logistics centers (dry ports), e08- Riga sea port, e09- Ventspils sea port, e10- Liepaja sea port, e11- Riga international airport.

Figure 1. Hierarchical depiction of the selection process for the investment objects (direct hierarchy)

In the cells S7:S11 of the electronic spreadsheet (Figure 2), the elements of the main own vector of matrix are calculated as the average geometrical values of each line in the matrix, e.g. S8= (B8*C8*D8*E8*F8)^1/S3). In the cell S22 the sum of the average geometrical values is calculated. In the range Q7:Q11, the values of elements of the priorities' vector are calculated by normalizing main own vector: Q7=S7/S22; Q8=S8/S22, and so on. In the cell S4, the main own value of the matrix λ_{max} is calculated by using a formula (2). The vector row A22:F22 is multiplied by vector column Q7:Q11. In the cell S1, the index of the consistency is calculated by using a formula (3). An algorithm was used to choose a statistical index of consistency CIS (cell S5), by which the value of the Table (2) data is selected. Consistency ratio is calculated by formula (4): S2=S1/S5.

In case if the consistency ratio is greater than 0.1… 0.2, the perceptions consistency is violated and the condition of transitivity for pair comparison matrices is not observed; the perceptions should be reviewed. The electronic table will perform the calculations with the new data.

Substantially that means that experts graded the influence of a01 at four times lesser than a02, when compared the influence of a01 and a02 on the hierarchy element p01. After entering the pair comparison matrix's rank in the cell S3, all the other calculations will be performed automatically.

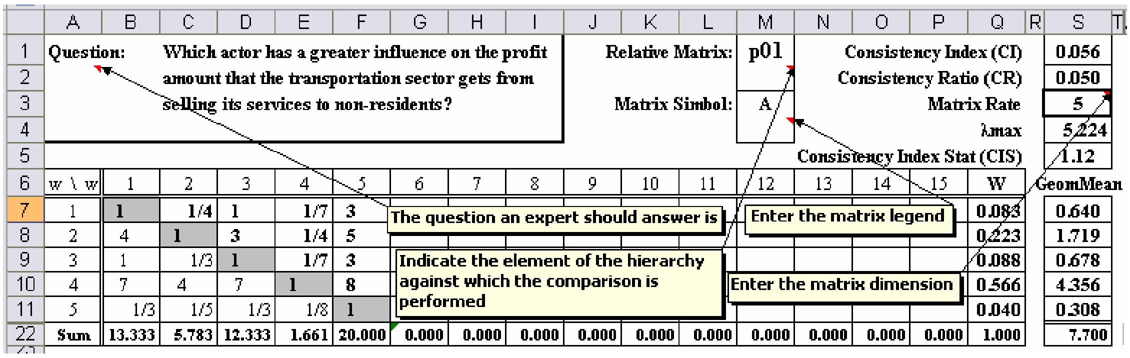


Figure 2. An example of the pair comparison table

Starting from the Level II, there is a general matrix for each hierarchy level: Level II- matrix P, Level III- matrix A, Level IV- matrix T, and Level V- matrix E. General matrices (Figure 3) are composed by the priorities vectors of the pair comparison matrices. E.g. the first column of the matrix A corresponds to the column vector calculated in the range Q7:Q11 of the electronic spreadsheet (refer to Figure 2). The row quantity in the matrix corresponds to the number of the elements in a given hierarchy level, and the column quantity corresponds to the number of the elements on the upper standing level. The calculation of the general priorities vector for the hierarchy Level V is performed by a formula (5): column vector (AP) is derived from multiplying matrix A by the column vector P, vector (T(AP)) is received by multiplying matrix T by column vector (AP), and by multiplying matrix E by (T(AP)) the vector of global priorities for the considered matrix is received. Consequent multiplication of the matrices was performed in MS Excel using the MMULT function. The values of the general priorities for each element in the hierarchy are displayed on the Figure 1. Experts assume in case of receiving the funds from the World Bank, the first choice would be the most costly project: developing an international toll highway M9: Baltic Highway all the way through Latvia (Kaliningrad- Klaipeda- Liepaja- Riga- Velikie Luki- Volokolamsk- Moscow).

P	
1	0.218
2	0.715
3	0.067

A	p01	p02	p03
1	0.083	0.240	0.053
2	0.223	0.575	0.275
3	0.088	0.069	0.095
4	0.566	0.054	0.029
5	0.040	0.062	0.548

T	a01	a02	a03	a04	a05
1	0.382	0.000	0.000	0.000	0.000
2	0.262	0.000	0.024	0.000	0.000
3	0.190	0.000	0.000	0.000	0.000
4	0.000	0.238	0.000	0.000	0.000
5	0.000	0.415	0.236	0.000	0.000
6	0.000	0.139	0.101	0.000	0.000
7	0.000	0.120	0.162	0.000	0.000
8	0.000	0.053	0.062	0.000	0.000
9	0.000	0.035	0.038	0.000	0.000
10	0.000	0.000	0.377	0.000	0.000
11	0.078	0.000	0.000	0.188	0.058
12	0.059	0.000	0.000	0.756	0.719
13	0.029	0.000	0.000	0.056	0.223

E	t01	t02	t03	t04	t05	t06	t07	t08	t09	t10	t11	t12	t13
1	0.202	0.000	0.038	0.068	0.043	0.000	0.069	0.433	0.222	0.000	0.060	0.185	0.173
2	0.019	0.000	0.017	0.000	0.019	0.040	0.000	0.000	0.000	0.000	0.023	0.185	0.173
3	0.079	0.000	0.062	0.233	0.105	0.000	0.241	0.000	0.222	0.021	0.268	0.103	0.092
4	0.018	0.000	0.013	0.016	0.030	0.021	0.241	0.000	0.309	0.021	0.268	0.013	0.011
5	0.295	1.000	0.306	0.043	0.273	0.390	0.166	0.025	0.022	0.318	0.178	0.025	0.167
6	0.000	0.000	0.059	0.000	0.000	0.000	0.037	0.000	0.000	0.032	0.023	0.000	0.018
7	0.000	0.000	0.000	0.000	0.015	0.026	0.118	0.000	0.000	0.045	0.039	0.039	0.035
8	0.093	0.000	0.106	0.129	0.189	0.227	0.017	0.082	0.064	0.148	0.039	0.064	0.054
9	0.093	0.000	0.106	0.071	0.068	0.091	0.013	0.082	0.040	0.095	0.039	0.064	0.054
10	0.093	0.000	0.106	0.071	0.068	0.147	0.026	0.139	0.031	0.095	0.039	0.064	0.054
11	0.109	0.000	0.187	0.369	0.189	0.059	0.073	0.238	0.088	0.225	0.023	0.256	0.170

Figure 3. General matrices of priorities

As an instrument for building up possible strategies or policies, a matrix of reverse process is developed (Figure 4). Using the terms of theory of decision-making [x], three types of variables may be identified: *planning policies, outcomes* that may take place in the future and *effectiveness*; these express the probabilistic correlations between planning policies and outcomes. According to [x] for the projected processes the policies are defined, effectiveness is assessed, and the outcomes are concluded, for desired processes the outcomes are assessed, effectiveness is tried, and policies are developed. The difference is based on the ways of organizing the problem in each different case. The organizing approach in both processes is hierarchal; however, the relationships of domination are reverse.

Figure 4 shows that the new global goal (focus) is the desired future process of building the Baltic highway; some strategies and policies are suggested (Level VI, the lowest) in order to achieve the desired objectives. Taking into account the international experience in building highways, the Level II of the hierarchy has four alternatives of PPP, in which two factors were combined: 1) receiving or not a fixed share of profit from exploiting the highway by territorial entities and 2) influence degree of Latvian governmental institutions on the tariff rate policy. In fact, the alternatives of PPP are the terms that may attract the foreign shareholders who will be ready to invest millions in development of Latvian highways. The Level III of the hierarchy depicts the problems that the project initiators may face while moving forward. Only five were selected from the number of possible ones, the problems that may require monetary settlements or payments. The fourth level of the hierarchy is actors. The list of actors differs from the one in the direct process. The Level V is the actors' goals and objectives.

Algorithm of calculations does not differ from the earlier described process: creating reverse-symmetrical pair comparison matrices for each level of hierarchy, calculating priorities' vectors and consistency rates, creating general priorities' matrices, calculating general weight for each element of the hierarchy.

5. Conclusions

The given research focuses on the algorithmic aspect of AHP. The scenario which shows the possibilities of the method is conventional; therefore the interpretation of the results permits the theoretical conclusions only.

The global priorities calculated for the direct hierarchy (refer to Figure 1) show:

1) The major portion of input into the Latvian GDP from the transportation industry is done indirectly (creates possibilities for service and retail companies to generate profits).

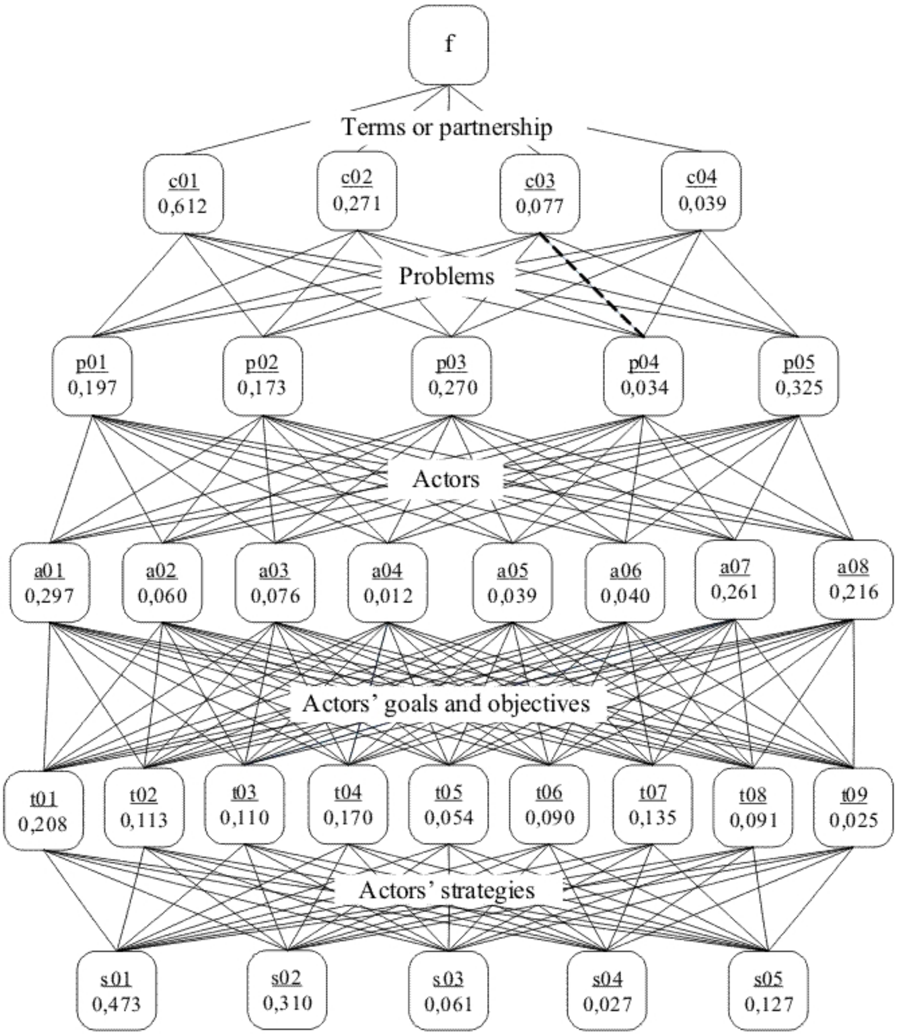
2) The major influence on the transportation industry and its the ability to generate its share in the GDP is initiated by the political parties and their sponsors, and the industry specialists and transport industry customers in Latvia have the slightest influence.

3) The actors' goals are contradictory (receiving illegal income and maintaining reasonable prices at the high level of service); the priorities indicate the ones in charge of decision-making in the transportation industry are corrupted.

4) Priority of the investments in the construction of the international toll highway and expansion of the Riga international airport shows that first of all the actors with the most weight are interested in creating favourable conditions for the foreign businesses and their partnering companies in Latvia.

Calculated global priorities for the reverse hierarchy are used for the repeat iteration of the direct process. Priorities of the repeat direct process are reviewed from the level of goals, and, if there is a level of policies, review starts from that lower level. Further, the priorities of the general outcome in the repeat direct process are compared to the priorities of the priorities of the desired future status of the first reverse process in order to see if the logical future result is getting close to the desired one. If this does not happen, then the second iteration of the reverse process is performed. During this iteration, the priorities of the desired future statuses are changed and/or the new policies are tried. The elements that receive the most weight again will be used for the third iteration of the direct process. Scenario's priorities are calculated and compared to the priorities that were derived from the second iteration of the reverse process. The procedure should be carried out till all the possibilities for the increase of probability of the logical outcome are tried.

The actors' global priorities of the strategies (policies), which values are shown on Figure 4, indicate that the project of developing Baltic highway can be completed if the actors will adhere to the strategy of attracting the foreign investments actively, and stay with the policy that provides for availability of the Latvian goods at the Russian market.



I. *Global goal (focus)*: building the M9 highway.
II. *Partnership terms:* c01- profits and influence, c02- only profits, c03- only influence, c04- nothing.
III. *Problems:* p01- buying out private land lots, p02- compensation of the negative affect on environment, p03- conformity with local authorities, p04- protests of the bordering countries, p05- protest of the political opponents.
IV. *Actors*: a01- political parties and their sponsors, a02- international financial and political organizations, a03- transportation industry specialists, 04- leading institutions in Russia, a05-investors, a06- transport and shipping companies, a07- local authorities, a08- population in the area of construction.
V. *Actors' goals and objectives*: t01- financing parties, t02- improving welfare of Latvian population, t03- preserving environment, t04- creating new jobs, t05- profitable investments, t06- stimulation of the traffic via Latvia- people and cargo, t07- additional income to the budget at all levels, t08- efficient cargo deliveries from east Baltic sea ports towards Moscow direction, t09- development of the Kaliningrad region.
VI. *Actors' strategies*: s01- attracting foreign investors, s02- availability of the Latvian goods at the Russian market, s03-limiting economical and political influence of Russia in Latvia, s04- "always" adhere to the policies that comply with the interest of the countries- donors, s05- stimulate the active life style among the population.

Figure 4. Hierarchal depiction of the progression process of the Baltic highway project (reverse hierarchy)

The method of hierarchy analysis allows analysing the problems, gathering all the data related to the problem, assessing contradiction of the data and minimizing it, performing synthesis of decision-making problem, organizing consensus-achieving collaboration, evaluating the importance of the accountability and the significance of each priority-influencing factor, estimating the stability of each decision, and performing the direct and reverse processes of planning.

It is possible to use Microsoft Office Excel to create pair comparison matrices and calculations used in AHP; however, to solve a task such as research and planning the development of the transportation industry of a country, ideally, a specialized computing program should be developed that also should be linked to a necessary databases.

References

1. Latvijas Republikas Ekonomikas ministrija. Centrālā statistikas pārvalde. *Saimniecisko darbību statistikā klasifikācija NACE 2. red*. – www.csb.gov.lv
2. Kotler, F. *Principles of Marketing*. Moscow: Progress, 1990. 736 p.
3. Golts, G.A. Culture, economy, transport: using their interrelations in forecasting, *Studies on Russian Economic Development*, Vol. 11, No 1, 2000, pp. 100-110.
4. Goltz, G.A,, Kartavenko, G.G. Macroeconomics and transport: cross-country comparisons and patterns, *Bulletin transport information. Information and practical magazine*, No 11(161), 2008, pp. 25-35. (In Russian)
5. McConnell, C.R., Brue, S.L. *Economics: Principles, Problems and Policy, 14th edition.* Moscow: Infra-M, 2004. 972 p. (In Russian)
6. Totsenko, V.G. *Methods and decision support systems.* Kiev: Naukova Dumka, 2002. 381 p. (In Russian)
7. Saaty, T.L. *The Analytic Hierarchy Process*. NY: McGraw Hill, 1980. 278 p.
8. Transport Ministry of the Republic of Latvia. The Basic Regulations of Transport Development in Latvia 2000-2013. Riga, Latvia. (In Latvian) – http://sam.gov.lv
9. Ministry of Transport of Russia. Development strategy of Transport of Russia until 2010. Characteristics of the priority projects of the transport sector (Annex 4). Moscow. (In Russian) – http://www.mintrans.ru
10. Saaty, T., Cairns, K. *Analytical Planning. Organization Systems*. Moscow: Radio and Communications, 1991. 224 pp. (In Russian)
11. Kolpakov, V.M. *Theory and practice of management decisions.* Kiev: Radio and Communications, 1991. 504 p. (In Russian)
12. Kenneth, J. *Social Choice and Individual Values.* Moscow, 2004. 204 p. (In Russian)

Transport and Telecommunication, 2009, Volume 10, No 4, 28–34
Transport and Telecommunication Institute, Lomonosova 1, Riga, LV-1019, Latvia

INVESTIGATION OF MATHEMATICAL MODEL OF COMMUNICATION NETWORK WITH UNSTEADY FLOW OF REQUESTS

A.N. Tuenbaeva[1], A.A. Nazarov[2]

[1]Kaliningrad State Technical University
Sovietsky prospect 1, Kaliningrad, 236000, Russia
e-mail: tuenbaeva_aiya@mail.ru
[2]Tomsk State University
Lenin prospect 36, Tomsk, 634050, Russia
e-mail: aanazarov@sibmail.com

When choosing structures and characteristics of computer networks in practice, frequently priority is given to the classical techniques and decisions. However, a closer research and disclosure of potential opportunities of networks of data transmission, is promoted by carrying out mathematical modeling.

In this work, mathematical models of computer networks of casual access in the form of mass service systems with a source of repeated calls and the notification about the conflict are constructed. A modified method of asymptotic analysis to investigate mathematical models of casual access network was developed.

The practical value of the work consists in the results of scientific research to promote carrying out a complex analysis, an optimization and a disclosing of potential opportunities of telecommunication systems of data transmission.

Keywords: random access, unsteady flow, asymptotic analysis

1. Introduction

The improvement of data processing is one of the most challenging problems for computer network creators and developers [1, 2]. Therefore, the research in the field of computer networks functioning is important nowadays. More precisely, problems related to unstable functioning, repeated transmission, collision and characteristics of input and output data flows in those networks are being investigated [3]. Mathematical modeling gives the possibility to predict the behavior of the network under certain conditions without the physical realization of the network itself. This allows you to save money both at the stage of modernization or establishment of a network connection, and at its further exploitation. The study of information processes, occurring in real networks of random access, should be carried out through random processes due to the presence of random effects. Therefore, to investigation such systems the most efficient tool of analytical modeling is a mass service theory [4, 5].

Among all the possible methods of the greatest interest are methods of research, which allow obtaining analytical expressions for the probabilities of the states of a simulated network. In this paper we use mathematical modeling of multiple access protocols for defining the basic probabilistic characteristics of such networks.

2. The Mathematical Model of Random Access Networks with Unsteady Flow of Requests

As a mathematical model of computer networks let us consider the mass service system (MSS) with the repeat requests source (RRS) [6]. There is one service device, which simulates the overall channel, the service time of which has an exponential distribution with parameter $\mu = 1$.

The unsteady flow of requests arriving at the entrance of the system is an unsteady process with parameter $\rho_1(t)$.

Each arrived request is immediately started to receive the service if the device is free. On the other hand, if the device is busy, the access conflict (a collision) occurs and both requests go to RRS, the staying time in which has an exponential distribution with parameter γ. A simulation program was realized when creating a model of random access network. The program helps to show that the assumption about an exponential distribution in RRS does not contradict the hypothesis of the invariance of the distribution of the state probabilities of the device to a type of distribution of the length of the delay in RRS.

Since the conflict occurs in the channel, the conflict notification stage is started to be transmitted, the duration of which has an exponential distribution with parameter $\mu_1 = 1/a$.

We define the following vector $(i(t), k(t))$, where $i(t)$ is the request number in RRS and $k(t)$ the state of the device. The state of the device can take 3 values:

$$k(t) = \begin{cases} 0, \textit{ the device is free}, \\ 1, \textit{ the device is busy}, \\ 2, \textit{ the device has the conflict state}. \end{cases}$$

The state of the network is defined as a two-dimensional vector $(i(t), k(t))$ and the changes in the states $(i(t), k(t))$ are Markovian.

Because the network that we study is controlled by static random multiple access protocol, for any set of parameter values $\rho_1(t), a, \gamma$ for this MMS there is no stationary regime.

Consider the non-stationary probabilities

$$P_k(i,t) = P\{k(t) = k, i(t) = i\},\ k = \overline{0,2},\ i \geq 0\,.$$

These probabilities satisfy the following differential system of finite-difference equations with variable coefficients:

$$\frac{\partial P_0(i,t)}{\partial t} + (\rho_1(t) + i\gamma)P_0(i,t) = P_1(i,t) + \frac{1}{a}P_2(i,t),$$

$$\frac{\partial P_1(i,t)}{\partial t} + (1 + \rho_1(t) + i\gamma)P_1(i,t) = \rho_1(t)P_0(i,t) + (i+1)\gamma P_0(i+1,t), \tag{1}$$

$$\frac{\partial P_2(i,t)}{\partial t} + \left(\rho_1(t) + \frac{1}{a}\right)P_2(i,t) = \rho_1(t)P_2(i-1,t) +$$

$$+ (i-1)\gamma P_1(i-1,t) + \rho_1(t)P_1(i-2,t).$$

The solution of the system (1) sufficiently defines the operation of a mathematical model of the network connection, but, unfortunately, accurate analytical methods for solving the system do not exist. Therefore, to study the system some authors have proposed a modified method of asymptotic analysis of Markovized systems [7].

3. Asymptotic Sstudy of a Mathematical Model of the Network with Unsteady Flow of Requests

Consider an unsteady flow, the parameter of which is a slowly varying function of time:

$$\rho_1(t) = \rho(\gamma t)\,.$$

We introduce the following notation $\gamma = \varepsilon$, $\varepsilon t = \tau$, where ε is a positive small parameter. We define $x = x(\tau, \varepsilon)$ and $x(\tau)$ as follows:

$$x(\tau,\varepsilon) = \varepsilon \times i\left(\frac{\tau}{\varepsilon}\right) \text{ and } x(\tau) = \lim\nolimits_{\varepsilon \to 0} x(\tau,\varepsilon)\,.$$

In our first result we show that under appropriate technical conditions, the process $x(\tau)$ exists and is a deterministic function with meaning of the asymptotic average of normalized number of requests in RRS.

In the system (1) we set $x = x(\tau,\varepsilon) = \varepsilon \times i(\frac{\tau}{\varepsilon}) = \varepsilon \times i$,

and $P_k(i,t) = \varepsilon \times \pi_k(x,\tau,\varepsilon)$. For further use, we also set $\pi(x,\tau,\varepsilon) = \sum_{k=0}^{2} \pi_k(x,\tau,\varepsilon)$.

Then we obtain system (2) below:

$$\varepsilon \frac{\partial \pi_0(x,\tau,\varepsilon)}{\partial \tau} + (\rho(\tau)+x)\pi_0(x,\tau,\varepsilon) = \pi_1(x,\tau,\varepsilon) + \frac{1}{a}\pi_2(x,\tau,\varepsilon),$$

$$\varepsilon \frac{\partial \pi_1(x,\tau,\varepsilon)}{\partial \tau} + (1+\rho(\tau)+x)\pi_1(x,\tau,\varepsilon) =$$

$$= \rho(\tau)\pi_0(x,\tau,\varepsilon) + (x+\varepsilon)\pi_0(x+\varepsilon,\tau,\varepsilon), \tag{2}$$

$$\varepsilon \frac{\partial \pi_2(x,\tau,\varepsilon)}{\partial \tau} + \left(\rho(\tau)+\frac{1}{a}\right)\pi_2(x,\tau,\varepsilon) = \rho(\tau)\pi_2(x-\varepsilon,\tau,\varepsilon) +$$

$$+(x-\varepsilon)\pi_1(x-\varepsilon,\tau,\varepsilon) + \rho(\tau)\pi_1(x-2\varepsilon,\tau,\varepsilon).$$

Let us assume that the following limits exist:

$$\lim_{\varepsilon\to 0} \pi_k(x \pm j\varepsilon,\tau,\varepsilon) = \pi_k(x,\tau), \quad k = 0,1,2; j = -2,-1,0,1$$

In the system (2) we let $\varepsilon \to 0$.

The result is a system of linear algebraic equations which solution (because of its homogeneity) can be written as

$\pi_k(x,\tau) = R_k(\tau)\pi(x,\tau), \quad k = \overline{0,2}$, with $R_0(\tau) + R_1(\tau) + R_2(\tau) = 1$.

The explicit form of the probability distribution of the states of the device $R_k(\tau), k = \overline{0,2}$ is given by:

$$R_0(\tau) = \frac{1+G(\tau)}{aG^2(\tau)+2G(\tau)+1},$$

$$R_1(\tau) = \frac{G(\tau)}{aG^2(\tau)+2G(\tau)+1}, \tag{3}$$

$$R_2(\tau) = \frac{aG^2(\tau)}{aG^2(\tau)+2G(\tau)+1},$$

where $G(\tau) = \rho(\tau) + x(\tau)$.

Now we have to determine $\pi(x,\tau)$.

To this end, in (2) we expand the functions $\pi_k(x \pm \varepsilon,\tau,\varepsilon), \quad k = \overline{0,2}$ into a series. Summing all the equations of the system, we get the following equality:

$$\varepsilon \frac{\partial \pi(x,\tau,\varepsilon)}{\partial \tau} = -\varepsilon \frac{\partial}{\partial x}\{[-xR_0(\tau) + \rho(\tau)R_2(\tau) + (x+2\rho(\tau))R_1(\tau)]\pi(x,\tau,\varepsilon)\} + o(\varepsilon).$$

Dividing both sides by ε, and then taking the limit $\varepsilon \to 0$, we get the equation

$$\frac{\partial \pi(x,\tau)}{\partial \tau} = -\frac{\partial}{\partial x}\{[\rho(\tau) + G(\tau)(R_1(\tau) - R_0(\tau))]\pi(x,\tau)\}.$$

This equation coincides with the degenerate Fokker-Planck equation concerning the asymptotic density of the distribution $\pi(x,\tau)$ of a diffusion process $x(\tau)$ with diffusion coefficient equal to zero and transfer coefficient $A(x,\tau)$ of the type

$$A(x,\tau) = \rho(\tau) + G(\tau)(R_1(\tau) - R_0(\tau)).$$

Since the diffusion coefficient is equal zero, the random process degenerates to a deterministic function $x = x(\tau)$, which satisfies an ordinary differential equation

$$x'(\tau) = \rho(\tau) + G(\tau)(R_1(\tau) - R_0(\tau)),$$

or, using (3)

$$x'(\tau) = \rho(\tau) - \frac{\rho(\tau) + x(\tau)}{a(\rho(\tau) + x(\tau))^2 + 2(\rho(\tau) + x(\tau)) + 1} \tag{4}$$

with an initial condition.

Thus, we have shown that the process $x(\tau)$ is a deterministic function defined by the ordinary differential equation (4).

Depending on the considered system, the differential equation, that determines the sort of function with the meaning of the asymptotic average of normalized number of requests in RRS, may have one or more limiting points.

The studies have shown that in networks with random multiple access there may occur a phenomenon of bi-stability, which is characterized by the fact that two states of the many states of the network are determined - the points of stabilization [8]. In this case, the network operates as follows. The system is fluctuating in a neighborhood of a point of stabilization, and then, after a random move, is going to another point of stabilization, and then again returns to the first point of stabilization, etc. The probabilistic-time characteristics of the network in the neighborhood of one point of stabilization are acceptable, while in the neighborhood of other point they may deteriorate many times, and the network is functioning very poorly.

Let us define

$$y = y(\tau,\varepsilon) = \frac{1}{\varepsilon}\left(\varepsilon^2 \times i(\frac{\tau}{\varepsilon^2}) - x(\tau)\right) \text{ and } y(\tau) = \lim_{\varepsilon\to 0} y(\tau,\varepsilon).$$

We show that $y(\tau)$ is a diffusion process of autoregression, which has the meaning of deviations of the number of requests in RRS from the asymptotic average, that is a local approximation of the process of states' changes of the MMS.

The distribution of probabilities of states of the device $R_k(\tau), k = \overline{0,2}$ when $\varepsilon \to 0$, is a discrete Markov process, independent of the process $y(\tau)$.

Again we consider (1) and as before we take $\rho_1(t) = \rho(\gamma t)$. Now we choose $\gamma = \varepsilon^2$ and $\varepsilon^2 t = \tau$. We also set $P_k(i,t) = \varepsilon \times H_k(y,\tau,\varepsilon)$.

Then we obtain the following system (5) of equations:

$$\varepsilon^2 \frac{\partial H_0(y,\tau,\varepsilon)}{\partial \tau} - \varepsilon x'(\tau)\frac{\partial H_0(y,\tau,\varepsilon)}{\partial y} + (\rho(\tau) + x(\tau) + \varepsilon y)H_0(y,\tau,\varepsilon) = H_1(y,\tau,\varepsilon) + \frac{1}{a}H_2(y,\tau,\varepsilon),$$

$$\varepsilon^2 \frac{\partial H_1(y,\tau,\varepsilon)}{\partial \tau} - \varepsilon x'(\tau)\frac{\partial H_1(y,\tau,\varepsilon)}{\partial y} + (1 + \rho(\tau) + x(\tau) + \varepsilon y)H_1(y,\tau,\varepsilon) = \rho(\tau)H_0(y,\tau,\varepsilon) +$$

$$+ [x(\tau) + \varepsilon(y(\tau) + \varepsilon)]H_0(y + \varepsilon,\tau,\varepsilon), \tag{5}$$

$$\varepsilon^2 \frac{\partial H_2(y,\tau,\varepsilon)}{\partial \tau} - \varepsilon x'(\tau)\frac{\partial H_2(y,\tau,\varepsilon)}{\partial y} + \left(\rho(\tau) + \frac{1}{a}\right)H_2(y,\tau,\varepsilon) = \rho(\tau)H_2(y-\varepsilon,\tau,\varepsilon) +$$

$$+ [x(\tau) + \varepsilon(y-\varepsilon)]H_1(y-\varepsilon,\tau,\varepsilon) + \rho(\tau)H_1(y-2\varepsilon,\tau,\varepsilon).$$

We assume that the following limits exist:

$$\lim_{\varepsilon\to 0} H_k(y \pm j\varepsilon,\tau,\varepsilon) = H_k(y,\tau), k = 0,1,2; j = 0,-1,-2 .$$

We also assume that the functions $H_k(y,\tau),\ k=\overline{0,2}$ are twice differentiable functions of y. In the system of equations (5) we take limits as $\varepsilon \to 0$.

The solution of the new system of linear algebraic equations in the functions $H_k(y,\tau),\ k=\overline{0,2}$ we find as

$$H_k(y,\tau) = R_k(\tau)H(y,\tau),$$

where $H(y,\tau) = H_1(y,\tau) + H_2(y,\tau) + H_3(y,\tau)$ and where $R_k(\tau),\ k=\overline{0,2}$ are determined by (3). It remains to determine $H(y,\tau)$.

In (5) we expand the functions $H_k(y \pm j\varepsilon,\tau,\varepsilon),\ k=\overline{0,2};\ j=1,2$ in a series by increments of the argument y to within $o(\varepsilon)$ accuracy.

The solutions $H_k(y,\tau,\varepsilon),\ k=\overline{0,2}$ of system (5) are of the form:

$$H_k(y,\tau,\varepsilon) = R_k(\tau)H(y,\tau) + \varepsilon h_k(y,\tau) + o(\varepsilon). \tag{6}$$

To determine the functions $h_k(y,\tau),\ k=\overline{0,2}$, we get a system of linear algebraic equations. Its solution can be written as

$$h_0(y,\tau) = \frac{G(\tau)+1}{G(\tau)}h_1(y,\tau) - \frac{R_0(\tau)-R_1(\tau)}{G(\tau)}yH(y,\tau) - \frac{1}{G(\tau)}\{x'(\tau)R_1(\tau) + x(\tau)R_0(\tau)\}\frac{\partial H(y,\tau)}{\partial y},$$

$$h_2(y,\tau) = aG(\tau)h_1(y,\tau) + aR_1(\tau)yH(y,\tau) + \tag{7}$$

$$+ a\{x'(\tau)R_2(\tau) - \rho(\tau)R_2(\tau) - (2\rho + x(\tau))R_1(\tau)\}\frac{\partial H(y,\tau)}{\partial y}.$$

In (5) we expand the functions $H_k(y \pm \varepsilon,\tau,\varepsilon),\ k=\overline{0,2}$ in a series by increments of the argument y to within $o(\varepsilon^2)$ accuracy.

Summing of the system of equations, we get the following equality

$$\varepsilon^2 \frac{\partial H(y,\tau,\varepsilon)}{\partial \tau} - \varepsilon x'(\tau)\frac{\partial H(y,\tau,\varepsilon)}{\partial y} = \varepsilon\frac{\partial}{\partial y}\{(x(\tau)+\varepsilon y)H_0(y,\tau,\varepsilon) - \rho(\tau)H_2(y,\tau,\varepsilon) -$$

$$-(x(\tau)+\varepsilon y)H_1(y,\tau,\varepsilon) - 2\rho(\tau)H_1(y,\tau,\varepsilon)\} + \frac{\varepsilon^2}{2}\frac{\partial^2}{\partial y^2}\{x(\tau)H_0(y,\tau,\varepsilon) + \rho(\tau)H_2(y,\tau,\varepsilon) +$$

$$+ (x(\tau) + 4\rho(\tau))H_1(y,\tau,\varepsilon)\} + o(\varepsilon^2).$$

Substituting (6) and (7) into this equality, after simple transformations we get the following equation for $H(y,\tau)$:

$$\frac{\partial H(y,\tau)}{\partial \tau} = -\frac{\partial}{\partial y}\{A(G(\tau),\tau)yH(y,\tau)\} + \frac{B^2(G(\tau),\tau)}{2}\frac{\partial^2 H(y,\tau)}{\partial y^2}, \tag{8}$$

where $A(G(\tau),\tau)$ and $B^2(G(\tau),\tau)$ are given by:

$$A(G(\tau),\tau) = R_1(\tau)\frac{1-2R_0(\tau)}{G(\tau)}, \tag{9}$$

$$B^2(G(\tau),\tau) = (G(\tau)-\rho(\tau))R_0(\tau) + \rho(\tau)R_2(\tau) + (3\rho(\tau) +$$

$$+ G(\tau))R_1(\tau) + 2aR_1(\tau)\{\rho(\tau)R_2(\tau) + (\rho(\tau)+G(\tau))R_1(\tau) -$$

$$-(\rho(\tau)-R_1(\tau))R_2(\tau)\} + \frac{2(R_1(\tau)-G(\tau))}{G(\tau)} \times$$

$$\times\{(\rho(\tau)-R_1(\tau))R_1(\tau) + (G(\tau)-\rho(\tau))R_0(\tau)\}. \tag{10}$$

Equation (8) is the Fokker-Planck equation for the probability density $H(y,\tau)$ of the diffusion auto regression process $y(\tau)$, where the coefficients of transfer and diffusion are determined respectively by formulas (9) and (10).

Let us write the stochastic differential equation for the process $y(\tau)$:

$$dy(\tau) = \alpha(\tau)y(\tau)d\tau + \beta(\tau)dw(\tau), \tag{11}$$

where $w(\tau)$ is a standard Wiener process, and the coefficients $\alpha(\tau)$ and $\beta(\tau)$ are defined by equalities (9) and (10) with a given asymptotic average of $x(\tau)$, i.e.

$$\alpha(\tau) = A(\rho(\tau) + x(\tau), \tau),$$

$$\beta(\tau) = B(\rho(\tau) + x(\tau), \tau).$$

Explicit expression for the process $y(\tau)$ has the form

$$y(\tau) = \exp\left\{\int_0^\tau \alpha(s)ds\right\}\left\{y(0) + \int_0^\tau \beta(s)\exp\left\{-\int_0^s \alpha(u)du\right\}ds\right\}.$$

As usual, $y(0)$ is given the initial value solutions of differential equations (11), stochastically independent of the values of Wiener process $w(\tau)$.

4. Conclusion

Carrying out research as presented in this article, allows us to understand the nature of information processes that take place in real communication networks. The aim of the study is to find the probability distributions of different states of the investigated system. Knowledge of the probability distribution provides the most complete, in a probabilistic sense, description of the functioning of the model and allows calculating different characteristics of the system. These characteristics can be further used for development tasks, design, parameter optimization of networks with random multiple access protocol.

Thus, knowledge of the distribution of states of the investigated network gives us the possibility to predict and control the random processes that take place in networks. Using the obtained information about the investigated systems, we can control their operation in the future.

References

1. Olifer, V.G., Olifer, N.A. *Computer networks. Principles, technologies, protocols.* SPb.: Piter, 2004. 864 p.
2. Egea-Lopez, E., Martinez-Sala, A., Vales-Alonso, J., Garcia-Haro, J., Malgosa-Sanahuja, J. Wireless communications deployment in industry: a review of issues, options and technologies, *Computers in Industry*, V. 56, Issue 1, 2005, pp. 29-53.
3. *Queues: Flows, Systems, Networks. Proceedings of the International Conference "Mathematical Methods for Analysis and Optimization of Information Telecommunication Networks"*, Minsk, January 26-29, 2009, 282 p.
4. Artalejo, J.R. Accessible Bibliography on Retrial Queues, *Mathematical and Computer Modelling,* V. 30, Issue 1-2, 1999, pp. 1-6.
5. Artalejo, J.R., Gómez-Corral, A. *Retrial Queueing Systems: A Computational Approach.* Berlin Heidelberg: Springer, 2008. 318 p.
6. Seisenbekov, B.E., Tuenbaeva, A.N. Investigation of the mathematical model of a network of casual access with recurrent stream arrives, *Computational technologies*, V. 13. Special issue 5, 2008, pp. 106-111.
7. Tuenbaeva, A.N. Mathematical modelling of computer networks operated by reports of casual multiple accesses, *Doctoral dissertation*, 2007. 211 p.
8. Tuenbaeva, A.N. *Computer networks with random access.* Astana: ENU, 2006. 105 p.

Transport and Telecommunication, 2009, Volume 10, No 4, 35-41
Transport and Telecommunication Institute, Lomonosova 1, Riga, LV-1019, Latvia

ALGORITHM TO FIND THE SHORTEST PATH ON A HIGH-DIMENSIONAL GRAPH AND ITS APPLICATION FOR TIMETABLE INFORMATION SYSTEMS

Vladimir Vishnevsky, Roman Zhelezov

ZAO Research & Development Company "Information and Networking Technologies"
Staroalekseevskaja Str., 5-215, Moscow, 129626, Russia
e-mail: vishn@inbox.ru, ironromeo@mail.ru

We present architecture of a developed timetable information system and describe an original algorithm to find an optimal travel route on public transport.

Keywords: timetable information system, public transport, optimal travel route

1. Introduction

The level of timetable information service for passengers in Russian Federation is not perfect. Even within a specific transportation system (except air transport) a customer is not provided with searching a transfer route. This problem for the railway transport is much more complicated than for the air one since the number of railway stations is hundreds of times greater than the number of airports.

The problem of searching an intermodal route (using different modes of transport in conjunction, such as ships, aircraft, etc) is of a huge complexity [1-3]. It should be noted that the transport network in Russian Federation is the largest in the world and strongly heterogeneous. There are places which can be reached by air only. There are places where water transport is preferable, and places which can be reached by railway only. Thus development of the information system allowing to unify an information from the automated systems operating for different transport modes to get a full information on tickets and a route with possible changes is badly needed.

In Europe, the mostly spread system is HAFAS [4] used on the rail transport in several countries. HAFAS provides the satisfactory search results but they are not generally optimal. The main reason is that the system search algorithm is based on the heuristic methods to narrow the search space. At first step the system uses a static algorithm with limited transport data which leads to a result generally non-optimal.

The automated system developed by authors of this paper avoid some disadvantages of the existing information systems and is based on a special search algorithm and on actual, dynamically updated information on the timetables of all the kinds of transportation.

2. Automated Timetable Information System on the Public Transport

The developed timetable information system provides information obtained by Internet on the optimal route in public transport between any places within Russia. Information allows for possible change between routes, intermodal routes, timetable and tickets available. The timetable information system is a system of programs and program modules providing its operation [2].

The program system consists of the following components:

1. Specialized database for geographic information and timetables.
2. Data preparation aids for the timetable information system.
3. Aids to import data from the intermediate XML format.
4. System of administration aids.
5. The core module with realization of a route search algorithm.
6. Service of integration with other information systems:
   a) integration service operating on-line;
   b) emulator of an EXPRESS system terminal.
7. Information Internet portal to access the information system.

The specialized database includes geographic information, regularly updated timetables of the public transport and realization of some algorithms to work with data programmed in the form of the stored T-SQL procedures. The features of the timetable information system made it necessary to develop special **data preparation aids** – a program of a transport graph visual description. The program presents a Windows application to describe fragments of a transport graph. The program saves results as an XML file. For each region or transport company, we can create a separate XML file describing disposition of the transport nodal points. Thus, we can describe rail, bus or other type of a transport network by piecemeal.

After geographical data is prepared in an intermediate XML format, it is downloaded to the system by means of **the data import program**. The program processes data in XML format, connects to the system database and appends information on transport graph junctions. In details, the download process consists of the following steps: reading data from a file, data analysis, elimination of data ambiguity, the forming of an object structure, data saving. The import program consists of two functional modules:

1. Geographic data loader;
2. Timetable loader.

The algorithm to import geographic objects is programmed as follows:

1. Recognition of an object name and type;
2. Searching of objects with a similar name within a database;
3. Adding an object to the database;
4. Update of topological connections.

The algorithm to import timetables differs from object import by

1. Definition of data structure;
2. Data reading into an intermediate table;
3. Data object structuring;
4. Saving structures into database;
5. Correction of supplementary data.

If a route involves a station belonging to a hiperjunction the database is added with supplementary timetable record. In the process of route timetable import, transfer subgraph is updated in a special way.

By means of graph creating program, the database has been uploaded with a number of transport graph fragments (the total number is more than 20 000 junctions). It involves the majority of railway stations and stops in Russia and abroad and the main bus stations in some Russian regions.

The information inquire starts with the route parameter determination (departure and destination points, mode of transport, travel date, etc). After a customer specified the inquiry parameters and pressed the “Search” button, the parameters are transmitted to the route search module. Using descriptors of departure and destination points, the modules receives necessary information on geographic objects. First, the algorithm tries to find a direct (non-stop) route between given points. If it fails, the system uses the heuristic algorithm to find change-over routes. After possible routes with minimal number of changes are found, the system checks if each of them satisfies additional conditions with taking into account search parameters. This step of algorithm implementation accounts for run days, border crossing and transfer duration. For each possible route, a customer is provided with the information of departure and arrival time of the shortest travel.

On the final stage, the mostly preferable route is transmitted to a subsystem to interact with outer automated systems. The subsystem is intended to get information on tickets available. The ticket information is the most frequently updated part of the transport information. If throughput of the automated systems interconnection channel is limited, and data level is high, it is virtually impossible to import current ticket information from the outer automated systems. Thus, the tickets availability is checked on the final stage of the algorithm work and in the moment when the optimal route is found and it satisfies customer’s criteria. The interactive subsystem is composed of:

1. The integration module within the route search module;
2. The outer systems integration service;
3. Emulator of an EXPRESS terminal;
4. The outer system interaction control program.

In the subsystem, data is searched in a cache of completed inquiries first. The cache collects the results of previous inquiries to the outer systems and keeps them for set time. If data is not found in cache, the subsystem sends a request to the outer automated systems. A way to send a request depends on features of an automated system. The request can be synchronous or asynchronous. If it is **synchronous**, the serving process performs it immediately. If the interaction is **asynchronous**, the request is queued for further service. When the queue is formed, the interaction service program starts processing it. A request from the queue is transformed into inquire in accordance with a protocol understandable for the outer automated system and is sent there. For example, to communicate with EXPRESS system, the special service is used, namely an emulator of an EXPRESS terminal. A service transforms the inquire into BSC-3 packets, encapsulates them into TCP/IP packets and transmits them to the EXPRESS access gateway. The gate communicates with a host PC and returns an answer to the terminal emulator. The process goes asynchronously, one inquire may result in series of questions and answers between the emulator and the host PC. Several services can work simultaneously, and they can be run on several PCs looking through a common queue of inquires.

To get timetable information via Internet, we have developed a portal to access the timetable information system. The portal gives information on a route by air or bus with possible changes of transport within Russia and abroad, including

- Searching for change points when there is no direct route between departure and arrival points;
- Searching the optimal travel date according to traffic days;
- Searching for routes between two points using different criteria (time in way, price and others);
- Searching for intermodal routes (with using different transport modes);
- Taking into account border crossings during route search;
- Providing information on a station timetable;
- Imaging the found routes on an interactive map;
- Imaging an interactive scheme of direct routes for a given station.

3. Algorithms for searching optimal paths on passenger transport

The new algorithm is used in developed timetable information system. Two main approaches are well known for modelling timetable information as shortest path problem: the time-expanded, and the time-dependent approach [5, 6]. The common characteristic of both approaches is that a query is answered by applying some shortest path algorithm to a suitably constructed graph. A time-expanded graph is constructed by assigning a specific time event (departure or arrival at a station) for every node. Edges between nodes represent either elementary connections between two events, or waiting within a station. Depending on the optimization criterion, the construction assigns specific fixed lengths to the edges. This usually results in the construction of a huge graph. As far as time-dependent graph is concerned the idea is to refrain from the creation of a node for every event. In the time-dependent graph model based on stipulation that every node represents a station, and two nodes are connected by an edge if the corresponding stations are connected by an elementary connection. The length on the edges is assigned in real time during request and depends on the time in which the particular edge will be used by the shortest path algorithm to answer the query. The timetable problem operate with objects of classes: stations, routes, arrival and departure times and traffic days schedule. The problem can be depicted by expression more formally: there are a set of routes *Z*, a set of stations *B* and a set of connections *C*. The connection is a combination of five values $C=(Z,S_1,S_2,t_d,t_a)$. This tuple is interpreted as train *Z* leaves station S_1 at time t_d, and the next stop of train *Z* is station S_2 at time t_a. A timetable is valid for a number of *N* traffic days, and every train is assigned a bit-field of *N* bits determining on which traffic day the train operates. At a station $S \in B$ it is possible to transfer from one train to another only if the time between the arrival and the departure at that station *S* is larger than or equal to a given, station-specific, minimum transfer time, denoted by transfer(*S*). Between stations that are located close to each other it is possible to walk by foot. Such data is available through so-called foot-edges between stations. Each foot-edge is associated with a natural number representing the time in minutes needed for the walk. Formally, we treat a foot-edge like an elementary connection *c*, where the train *Z* and the departure and arrival times t_d and t_a are invalid, and length(*c*) is the associated walking time.

Let $P=(c_1,...,c_k)$ be a sequence of elementary connections (and foot-edges) together with departure times $dep_i(P)$ and arrival times $arr_i(P)$ for each elementary connection $c_i, 1 \le i \le k$. We assume that the times $dep_i(P)$ and $arr_i(P)$ include data regarding also the departure/arrival day by counting time in minutes from the first day of the timetable. A time value *t* is of the form $t=a*1440+b$, where $a \in [0, 364]$ and $b \in [0, 1439]$. Hence, the actual time within a day is t (mod 1440) and the actual day is $\lfloor t/1440 \rfloor$. Such a sequence *P* is called a consistent connection from station $A=S_1(c_1)$ to station $B=S_2(c_k)$ if it fulfills some consistency conditions: the departure station of c_1+1 is the arrival station of c_i, and the time values $dep_i(P)$ and $arr_i(P)$ correspond to the time values t_d and t_a, of the elementary connections (modulo 1440) and respect the transfer times at stations.

More formally, *P* is a consistent connection if the following conditions are satisfied:

$$
\begin{gathered}
c_i \ valid \ 1 \ day \ [dep_i(P)/1440], \\
S_2(c_i) = S_1(c_{i+1}), \\
dep_i(P) \equiv t_d(c_i)(\bmod 1440), \\
arr_i(P) = dep_i(P) + length(c_i), \\
dep_{i+1}(P) - arr_i(P) \geq \begin{cases} 0, & if \ Z(c_{i+1}) = Z(c_i) \ or \ c_i - foot \ edge, \\ transfer(S_2(c_i)), & othetwise. \end{cases}
\end{gathered}
$$

The most well-known problem is an **earliest arrival problem**. The request (A, B, t_0) defines departure *A* and arrival *B* stations and departure time t_0. The goal is to minimize the difference between the arrival time and the given departure time. In another problem the goal is to find the route with the minimal number of transfers on the way between *A* and *B*. In this problem the time of arrival and departure do not matter.

Designated approaches can be used for modelling a real problem, that takes into account the transfer time. To incorporate transfer times in the time-expanded model the realistic time-expanded graph is constructed as follows. Based on the time-expanded graph, for each station, a copy of all departure and arrival nodes in the station is maintained which we call transfer nodes. The stay-edges are now introduced between the transfer-nodes. For every arrival node there are two additional outgoing edges: one edge to the departure of the same train, and a second edge to the transfer-node with time value greater than or equal to the sum of the time of the arrival node and the minimum time needed to change trains at the given station. Many customers are interested in finding a cheapest connection from station A to B within a defined time interval. Unfortunately, a tariff rules in every countries are very complicated and a problem can not be solved exactly and efficiently at the same time. The multi-criteria optimization is needed then passenger plans route using several criteria. If one need route with minimal time in way and minimal number of transfers the target is to solve MOSP (multi-objective shortest path) problem. The problem is usually NP-hard, since the Pareto set is typically exponential in size even for simple graphs like chains. So, approximated methods are used in practice to find the solution for multi-criteria problem. One method to find Pareto optimal solution is using lexicographic order. With the simplified version of the time-expanded approach the lexicographically first solution can be computed for any *d*-tuples as edge weights. For example, if *d*=2, the first element being the travel time and the second one the number of transfers, among all fastest connections the one with the minimum number of transfers is computed. With the realistic version of the time-expanded approach only tuples can be used where the first criterion is travel time. Both approaches (time-extended and time-dependent) were thorough investigated in many papers. It is evident, that finding all suitable routes taking into account time in way, ticket price, number of transfers is much more complex, than earliest arrival problem. The investigations of performance for well-known methods show that performance is not enough to be used in real life tasks. The performance is a critical for timetable information systems that serve thousands requests in real time on web server.

Let enumerate some speed-up techniques that allow to improve performance of pathfinder algorithm. The **angle restriction** technique uses geo data including position of nodes. At first stage during data preprocessing Dijkstra algorithm is used in order to compute all shortest paths from every node. The results of computation are not saved, because task needs a huge amount of hard memory. Two angles for every node are saved instead $a(v,w)$ and $b(v,w)$. Let (v,w) be an edge from some event v to some other event *w*, and let S_v and S_w be the stations to which events *v* and *w* belong, respectively. Then the values $a(v,w)$ and $b(v,w)$ stored for edge (v,w) span a circle sector with center S_v in the plane, where, say, $a(v,w)$ is the right leg. The values $a(v,w)$ and $b(v,w)$ are determined such that this circle sector has the following meaning: if the shortest path from event *v* to some event *u* at some station S_0 contains (v,w), then S_0 has to be in this circle sector.

A **station subset** technique is used in many travel route planners [6]. As a result of applying this method the number of tested nodes decreases several times. Let $G = (V, E)$ be a transport graph, $V^{\sim}$ - a set of selected nodes, *G*'- auxiliary graph built on nodes set $V^{\sim}$. Auxiliary graph is generated on preprocessing stage. After that, all requests can be computed using generated graph and resulting path lengths will be equal to lengths on transport graph. The **goal-directed search** is one more speed-up technique. This strategy is based on one real number *b*(*s*) for each station *s*, which must be a lower bound on the minimal travel distance from s to the arrival station. Let λ – potential function (v, w) defined as $l(v, w) := l(v, w) - \lambda(v) + \lambda(w)$. The weight of edges changes to direct the search on graph to the target node.

The **hierarchical search** is similar to station subset technique, but uses several generated auxiliary graphs. Source graph $G = (V, E)$ split to l+1 level. Every level is extended with shortest paths between some nodes [10]. The Dijkstra algorithm uses the smallest graph in hierarchy in order to find shortest path. One more interesting is **reach** technique. Given a path P from s to t and a vertex v on P, the reach of v with respect to P is the minimum of the length of the prefix of P (the subpath from s to v) and the length of the suffix of P (the subpath from v to t). The reach of v, $r(v)$, is the maximum, over all shortest paths P that contain v, of the reach of v with respect to P. If reaches are calculated on preprocessing stage then results can be used for pruning during search requests. Such data allows to know in advance which edge to exclude.

4. Special algorithm for searching optimal passenger route.

Special algorithm that is used in timetable information system solve bicriteria problem with minimal number of transfers and earliest arrival time [1, 2] in lexicographical order. Algorithm operates with converted data and allows to solve the problem exactly. The search uses generated virtual transport graph that is similar to time-dependent model extended with auxiliary data. The advantage is auxiliary data can be recalculated locally. So, full preprocessing is not needed after some change in timetables and graph update can be done in real time. At the same time the above mentioned speed-up technique can not be used because the information about graph edges do not stored in system, but calculated in real time. Generally, Dijkstra algorithm can be applied to this graph, but the performance is not enough. For improving it special techniques were developed. **Transfer subgraph** technique is based on selecting potential transfer stations. During import source timetables, the data is analyzed and subgraph is updated. Developed criteria allows to make decision whether to add station to subgraph. This technique is similar to hierarchical technique but the subgraph can be updated in real time. One more effective technique is **bidirectional search balancing**. The idea of method is to make optimal decision whether to make direct or back step in bidirectional search. For special graph effective technique "**A***" can be adapted. Though it shows good practical efficiency, in general case this method does not guarantee the optimal solution. But then applied restriction on direct route lengths the method is **distance-preserving**. Distance-preserving speed-up technique has to guarantee optimal solution for problem.

Proposed approaches implemented in timetable information system "MARSHRUTY". Adoption of new technology allows strongly improve the quality of information service for passengers, optimize public transport traffic and loading.

The pictures demonstrating the work of information system are shown on Figures 1-3.

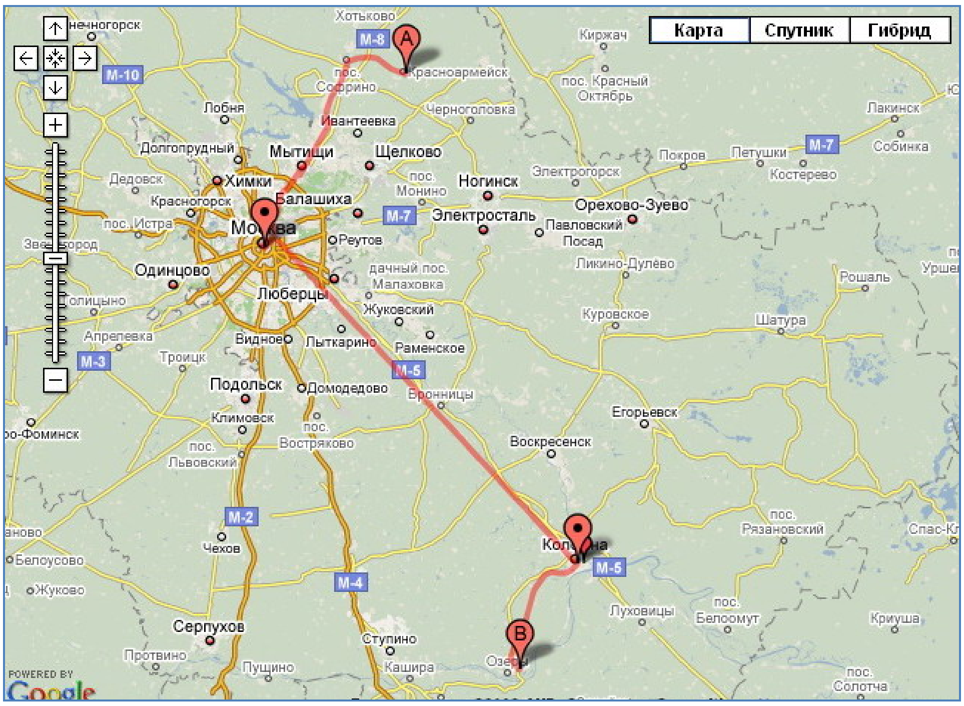


Figure 1.

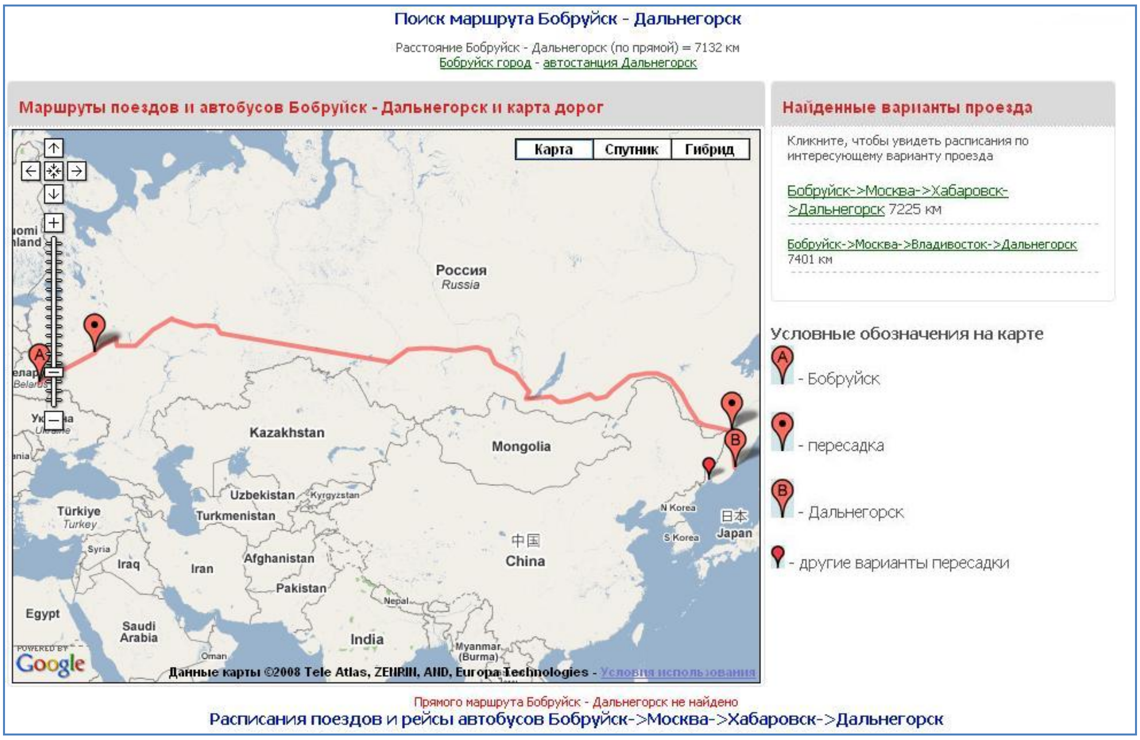


Figure 2.

Figure 3.

References

1. Vishnevsky, V.M., Zhelezov, R.V., Atanasova, T.N. Integrated timetable information system for railway transport in Russian Federation, *Distributed Computer and Communication Networks* (*DCCN-2005*), 2005, pp. 165-172.
2. Zhelezov, R.V. Realization of the integrated timetable information system on the base of Microsoft technologies, *Proceedings of the Conference «Microsoft Technologies in Programming Theory and Practice»*, Moscow, 2006, pp. 10-13.
3. Vishnevsky, M.V. *Theoretical design bases of computer networks*, Moscow, Technosphera, 2003. (In Russian)
4. HAFAS. A timetable information system by HaCon Ingenieurgesellschaft mbH, Hannover, Germany. http://www.hacon.de/hafas/.
5. Műller-Hannemann, M., Schulz, F., Wagner, D., Zaroliagis, C. *Timetable Information: Models and Algorithms in Algorithmic Methods for Railway Optimization*, Springer Berlin, Heidelberg, 2007.
6. Brodal, G. S., Jacob, R. Time-dependent networks as models to achieve fast exact time-table queries, In *Proceedings of the 3rd Workshop on Algorithmic Methods and Models for Optimization of Railways (ATMOS 2003)*, Vol. 92 of Electronic Notes in Theoretical Computer Science, Elsevier, 2004.
7. Cooke, K.L., Halsey, E. The shortest route through a network with time-dependent intermodal transit times, *Journal of Mathematical Analysis and Applications*, Vol. 14, 1966, pp. 493-498.
8. Wagner, D., Willhalm, T. Geometric speed-up techniques for finding shortest paths in large sparse graphs, In: *Proceedings of the 11th European Symposium on Algorithms (ESA 2003)*, Lecture Notes in Computer Science, Vol. 2832, 2003, pp. 776-787.
9. Wagner, D., Willhalm, T. Speed-up techniques for shortest path computations. In: *Algorithmic Methods for Railway Optimization*, Lecture Notes in Computer Science, Vol. 4393, 2007, pp. 23-36.
10. Zhelezov, R.V. Features of a transport route searching algorithm subject to timetable, Distributed Computer and Communication Networks. Theory and Applications (DCCN-2007), Moscow, 2007, pp. 28-32. (in Russian)

Transport and Telecommunication, 2009, Volume 10, No 4, 42–49
Transport and Telecommunication Institute, Lomonosova 1, Riga, LV-1019, Latvia

DECISION-MAKING IN CLOSED SYSTEM ENVIRONMENT ON THE BASE OF RISK DETERMINATION, LIKE A PART OF LOGISTICAL LEADERSHIP

Vladimirs Dreimanis

Latvian National Defence Academy
Ezermalas Str. 8, Riga, LV-1014, Latvia
Ph.: +371 67076881. E-mail: Vladimirs.Dreimanis@mil.lv;

One of the most typical representatives of closed systems is the military system. Furthermore, the military decision-making process is based on standard procedures that from the one side make the process more simple and achievable, bet from the other side – dogmatic and too structured, so necessity of changing it to more flexible and based on considerable achievements in logistic, leadership, telematics and computing sciences – became obvious. The historic fact is, that logistic as such is the result and consequence of ancient development of the theory of war or in other words – military science. Thus, looking at development of logistic up to scientific acknowledgment, it is the time to recognize that the modern logistic is not only some transportation and delivering services providing system, which need to be managed, but it is also separate self-regulating management, development, information and analyses system, that can be again obtained like the "Art of manoeuvring of troops" (Theoretist of French military science Jominie, XIX century, CE). The idea is to introduce Logistical Leadership (not equal to Logistical or Logistics management) like an administration system based on logistical science achievements that cross-integrates self-management, self-development, information analysis and decision-making processes and provides the profit of the most qualitative decisions in any applying area.

The main component of any management system is the decision-maker. More explicitly – his/her ability to understand the interaction of all three components of decision-making triangle is situation, resources (available tools), and human's/decision-maker's potentials. The hypothesis that the first two elements have no influence from the decision maker's side before a decision is made and a relative action taken concentrates our attention on the third one – a human. That approach has to be based not only on a creatively thinking individual, but also on scientifically approved methods of situation evaluation and risk analysis that have to be taken in use. Subsequently, we are finding ourselves in front of the task to create and optimise necessary tools and mathematic models that will allow to make correct choice of experts and to conduct qualitative analysis of information and risks, resulting with the most profitable, effective and faultless decisions – the target and the main product of an administration's system – Logistical Leadership.

Keywords: logistic management, decision-making, standard procedures, risk management

1. Introduction

In year 2005 in connection with Ottawa agreement The Denmark Cost directorate (Kystderektoratet) initiated process of cleaning the soil from hazardous objects remaining from WW2 at the western coastline of Denmark. The operation took place already in 2006 and many different agencies have been involved. But at the beginning it was unclear - whom, how, how deep, what area, etc. has to bee cleaned, because there were neither procedures nor experience to organize such a difficult operation – full profile demining at coastline. New supply roads and transportation issues, entrances and exits from demining and demolition areas, security zone and passing procedures (including air space and maritime areas connected to the field of operation), scientifically approved methods of demining and calculations of 3D area needed to be cleaned with given probability of clearance, etc. – those are the problems that organizers met. Now, looking into available documentation, there is no doubt that to solve these problems, in reality managers of operation used more or less principles of logistics. It is the fact that Logistics is one of the results of development of the ancient theory of war and is probably most developed and attractive management system in present, which can serve like a foundation for future development of universal administration system – Logistical Leadership. I this connection It is more-less understandable reason to choose "logistics" like a part of administration system, but why "Leadership"?

Speaking about any administration system we can not avoid the central figure of it – human. Managers, administrators, directors, chiefs, etc. – all of them are greater or less leaders. Each and all of them are on key positions that give access to information and situation analyses; – to distribution of priorities and resources; -to creation of plans and control of its' realization; – etc., but all those activities will sooner or later result with a decision, in particular those are the parts of one common process - decision-making. The decision-making is the process where many specialists take a part in. At the same time it is the process which needs to be organized, coordinated, administrated, managed etc. and not list –

leaded because at the end it will be often only the leader responsibility about quality of such decision-making and finally about decision he/her will made.

In closed system environments, like a military system, the decision-making will ask even more responsibility from decision maker – first and foremost because of safety and security aspects - respectively because of necessity to identify and to evaluate all the risks most possible accurately. Speaking about risk the most common definition of it is “lose” decision-making in condition of direct threat to one’s life makes identification and determination of risks to the most important part of the decision-making. Unfortunately the military forces are almost everywhere and every time under pressure of such conditions that is why evaluation of different risks has to become a non-separable part of military decision-making. That is why it’s very crucial to recognize all elements of such decision; to involve the most trustable exerts; to determine all possible problems and risks most accurately.

Risk determination in safety and security areas is not the same like in others areas, primary, once again, because of concentration on the possible threats to human life as such, then because of uncountable number of combinations of uncertainties, so because of impossibility to collect suitable statistic information for conducting pure mathematic analysis. The only method available in such conditions is use of experts, or education of future decision makers like experts in safety and security at the same time. Under circumstances of emergent necessity there is possibility to conduct qualitative risk determination, by use of specially created methodology for selection of experts, and compatible evaluation of results of expertise made by them. Creation of mathematical model and mathematical calculation of all necessary products of expert and/or expertise quality is an additional task and possibility of automatization of some decision-making processes – in this aspect logistical leadership system creation where computing can help effectively.

2. Logistical Leadership – Substantiation and Formulation

“Logistic is the process of planning, implementing and controlling the efficient, effective flow and storage of goods, services and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements” – formulation that Council of Logistic agreed on. Taking in account this standard formulation of logistics the two main areas of modern logistics can be identified:

Practical logistic – practical realization of definition, and

Logistics Science – scientific approach to the methods and mathematic models of distribution management (new science, has been actively developed since 80).

This is the statement that some authors insist on, but from my point of view (and point of view of reconstruction/ utilization of logistics like a basement of Logistical Leadership system), firstly – has to be turned bottom-up and formulated like primer – logistic science and then – practical implementation; and secondly – has to be seen only with interferences between and feed bucks from/to both of parts.

Agreed on that practical implementation of Logistical Science achievements is a subordinate process, which is an integral part of Logistics Science and will have “buck up” influence on it, but is not a leading substance of Logistics, we concentrate us on Logistical Science that accordingly spans numerous areas of modern logistics like:

- Raw material acquisition and supply management
- Production management
- Marketing
- Transportation, delivering and distribution management
- Information management and analysis
- Personal management
- Risk management

Each of these areas based on the main principles of Logistics management:

- Strategic positioning and support policy
- Continuity
- Cyclicity
- Functional interdependence
- Flexibility
- Cost-effectiveness
- Competence building and follow of technological development
- Rationalisms
- Integrity

But from my point of view the expression “logistics (or logistical) management” may be analysed with an adequate criticism If the formulation of logistics like a process of planning implementing and controlling… etc. – is the correct one we are agreed about so Logistics itself is the management system. Thus logistics management can be obtained like a bit confusing formula – management of management, although in some sources it’s formulated like “The design and administration of systems to control the flow of material, work-in-process and finished inventory to support business unit strategy” – pure tasks of Logistics itself. So to avoid any misinterpretation of such non-sense “management of management” formulation, I’ll utilize the above-described principles like principles of Logistics. Then once again – everyone administration/management system is created by human, utilized by human, and managed/administrated/leaded by human so the human/individual is one integrated (I even must stress – central) part of any such system. And it only depends on human ability if any system will function effectively or not.

“***Leadership*** is a process of social influence in which one person can enlist the aid and support of others in the accomplishment of a common task”, by Chemers, M.M. In another source we can find that “Leadership is a process by which a person influences others to accomplish an objective and directs the organization in a way that makes it more cohesive and coherent”.

Transactional and transformational leadership theories describe vertical or horizontal chain of command/relation between individuals in a team solving some given tasks. Identification of the types of leaders gives us the knowledge of imperative division to:

- Autocratic or Authoritarian Leaders, who centralize all the power of decision-making in his/her hands and do not ask for any suggestions or initiatives from subordinates;
- Participative or Democratic Leaders, who prefer “consultations” with team members before giving instruction;
- Laissez Faire or Free Reign Leaders, who actually not lead but motivate team members to use whole the spectrum of they knowledge and experience and provide maximum “freedom of movement”.

So which theory of leadership or what kind of leader type has to be used from the point of view of a closed administration system? In fact different situations ask for different leaders or more precise – different styles of leadership.

The autocratic one can be successful as it provides strong motivation to the manager, permits quick decision-making, although only one person decides and keeps each decision to himself until feels it is needed by the rest of the team. An autocratic leader does not trust subordinates. The democratic one prefers decision-making by the team, because he believes that can win from cooperation between team members and can motivate them effectively and positively. It costs more time and more knowledge from the leader himself. The Laissez Faire leaders do not lead from the point of view of close control to subordinates. They are given a freehand can use they own methods and realize own ideas. It’s possible in team with high level of trust and expertise, but asks from the leader absolute fidelity to subordinates and actually great aptitude in the area of leadership – to create self-regulating decision-making system.

In an emergency when there is no time for discussions to obtain an agreement and where a commanding officer has significantly more experience or expertise than the rest of the team, an autocratic leadership style is the most effective, at the same time, in a highly motivated team with a homogeneous level of expertise, a more democratic (up to laissez faire) style may be more effective. So the leadership style taken in use, while balancing the interests of members of the team, should be passed to current situation and provides most effective way to accomplish tasks or achieve the objectives given.

Why Leadership and not Management?

Through many publications and authors as well as both by theoreticians and by practitioners, the terminology of "management" and "leadership" have, in the context of administration of an organization, been used both as synonyms with clearly differentiated sense – after simplification – supervising, directing and controlling the process of accomplishment of the task. Generally speaking the fact that those two nouns are in used equally well indicates that there is a broad overlap between them. However the noun Leadership in my opinion describes not only involvement in process of management but also of creation of new innovative visions. From this angle I agree with expression that “Good leaders develop through and never ending process of self-study, education, training, and getting new experience”.

Taking in account all above mentioned The meaning of **Logistical Leadership** can be formulated like – **systematical approach to creation, administration and development of interdependent connections across any process to provide the most efficient and coherent planning, implementation and control with aim to accomplish tasks or achieve the objectives most effectively.**

Like it situated before the Logistical Leadership found on base of principles of Logistics, so it is logical consequence that the principles of Logistical leadership formulated similarly:

- Strategic positioning and vision production
- Based on Methodology, Scientific approach and Risk management
- Clear and adequate personal policy
- Cyclicity and Cost-effectiveness
- Flexibility and efficiency
- Functionality and Rationalisms
- Sustainability and Continuity
- Comprehensiveness and Interdependence
- Support and use of already existing resources
- Information exchange, Data collection, and tendency analysis
- Process Integrity

Logistical Leadership ≠ Logistics Management

3. Paradigms of Decision-Making in Closed System Environment

An individual is rational and analytic creature lives not only pushed by his/her instincts and feelings, but mostly leaded by his/her intellect. During live cycle we have to take uncounted numbers of decisions. Each person, organization or institution prefers to deal with the less risk affected way of action. There why the possibility to preview or even more to prevent risks, determined by scientifically approved methods, is highly evaluated by decision makers. One decision could be more important than others as well as more qualitative than the others. Decision-making is based on level of education and competency, area of duties, position in society, experience and skills of a decision maker as well as on his/her ability to utilize accessible recourses and taking advantage of modern technology and scientific approach to determination of all obstacles, positives and negatives influences, risks' and human factors.

The earlier military decision-making process has been based on philosophy of war, where two or more opposite sides try to push each other to some stand when one of the sides will have no more possibility to resist and will be physically forced to execute the winner's will. In modern time, when the concern about asymmetric threats is higher then about conventional war, saving the idea of military system like a closed system and centralization of power in military forces, the commanding officer both like leader and like decision-maker has still a privilege to take final decision and distribute orders about when, where, why and how subordinates have to act. But then again, the modern technology, use of "smart arms" and computers created situation when each soldier on the battlefield has to become decision-maker in individual area of responsibility.

10 steps to become 360 degrees leader

1. Take the tough job
2. Put in your time in the trenches
3. Be comfortable working in obscurity
4. Make an effort to get along with difficult people
5. Put your own reputation on the line
6. Admit your faults, never make excuses
7. Do more than is expected of you
8. Put out your hand and help someone else
9. Never, ever say, "That's not my job"
10. Follow through on your promises

Figure 1. 360 degrees leader

With the aim to synthesize a new approach for preparation of modern military decision-makers at all levels, the analysis of current situation on different levels of decision-making has been made several times. During conference "Human in command – 2000" among other opinions the idea of 360 degrees leader (Fig.1) was introduced and the question about qualities of military leader has been discussed from many aspects. Everyone was agreed that many abilities (Fig. 2) have to be at present when we speak about commanding officer position as a leader. But no one mentioned the commander duty to be not only a personal manager, system developer etc. but as well a decision-maker at the same time. Even more – no one stressed the necessity to delegate authority of decision-making through hierarchy of command down to simple soldier, who, as already mentioned, also de-facto becomes decision-maker in the field of his/her military profession and expertise, of individual development and experience.

able	courageous	good humoured	knowledgeable	practical	**smart**
accountable	creative	heroic	loyal	professional	spirited
action-oriented	decisive	honest	management	resilient	steady
adaptable	dependable	honour	mature	resolute	tough
alert to moral	determined	imaginative	moderate	respectful	trusted
issues	diligent	industrious	moral courage	responsible	trustworthy
analytical	dutiful	influential	not shy	ruthless	undaunted
can anticipate	dynamic	initiative	obstinate	**self-confident**	unflappable
articulate	eloquent	innovative	organizational	**self-**	valorous
assured	empowering	inspirational	skill	**controlled**	virtuous
audacious	energetic	inspiring	perceptive	**self-**	will
brave	expert	integrity	perseverant	**improving**	will power
competent	fit	intelligent	personal	selfless	willing to take
competitive	flexible	intuitive	integrity	self-reflective	risk
considerate	force of	inventive	physical	self-sacrificing	wise
cool-headed	character	judgment	courage	sincere	zealous

Figure 2. Leader's abilities

Decision-making in a closed system environment has other properties and more restrictions than in an open system. Usually there is even separate legislation specially created for such system, that from one side protects the system, but from the other side sets frames restricting utilization of closed system advantages. In such conditions it is very important to concentrate resources on system's qualitative skills.

The fact is that continuing follows the algorithm of soldiers training on the base of physical strength and military tactical skills, the militaries spontaneously more and more look on themselves like on well trained military equipment and weapons' operators and not just a warrior. In this case the set of different standing orders, regulations, rules, manuals, standards... etc. (generally speaking – standard procedures) does not meet anymore requirements of conducting modern military operations – real asymmetric warfare operations, due to uncounted number of variations of methods and sets of tools that can be used for its' accomplishment.

So – what kind of paradigms we are discussing about? The differences between human ability to follow "Standard procedures" as a decision-making process simplification – from one side and need for qualitative decision made by a creatively thinking professional – from the other one! Those differences are very simply describable taking as example above mentioned (Fig. 2) "in bold" written qualities. Contrary to qualities of decision-maker, the "standard procedures" ask from a "simple soldiers" to be:

- Non-analytical (take measures – look in database!)
- Non-expert (do what and how I said to do!)
- Non-creative (read manuals!)
- Non-innovative (follow prescriptions!)
- Non-inventive/smart (use standard tools! Don't has any? Ask for supply!)
- And finally – maybe self-confident, self…etc. but only when following the standard procedures.

As result to de-conflict psychological un-safety and comfortlessness for human boxed between aptitude for creativity (especially for well-educated person), and hard frame of standard procedures (made for purpose of being possibly used even by a monkey), there is a need first and foremost to change way of thinking and level of trust to single worker inside of closed system (soldier). This can be done by gradual implementation of "intellectual approach" methods into training and education system of leaders and also down to simple workers. We have to learn both ourselves and them do not fill any fear of make mistakes but use risk determination and management approach for diminishment of probability of making mistakes instead.

From another side we've to destroy conditions which at present support the system of standard procedures. For example, at the moment even our civilian control authorities (our respective ministries) use "Jawboning" to introduce rolls corresponding to peacetime civilian legislation that makes not differences between soldier's and ordinary worker's style of life although the first one "selling" his/her life to his country but the second one only his/her hands to employer.

Other areas that need to be reviewed are the following:

- Commander's responsibility for decisions made by subordinates (avoidance of situation when an incorrect decision made by a professionally trained military person could be a negative case for his/her commanding officer);
- Speculation around high cost of training process for "simple" soldier – that is also the pay for modern technology and live in high-developed society;
- Insurance policy (soldiers a priory is "designed" to be injured or killed in action, so let us don't be astonished about how it can happened and try to point at this soldier's own fault in such cases).

Finally, the "intellectual approach" methods shall mean in reality transition from the Standard procedures to methodology. And the simplest solution that can give results already in short-term is to implement two main trains in decision-making:

- Algorithms instead of standard procedures (not a way of doing but way of thinking);
- Manuals – only on the technical level of utilization of equipment or weapons (not "action" or "field" manuals).

4. Risk Determination

The military decision-making process covers decision-making in safety, security and defence areas. It has been always directed to quality of risk determination, for sure much more than in other areas, because here we are speaking about the most dramatic lose – human live.

The quality of such process is essential also because of growing involvement of civilians, who provide different services and necessary support to increase military abilities. Growing activities of CiMiC – the area, where civilian and military efforts have to be coordinated, ask for more attention and more security for civilians, thus for more precise detection, calculation and sequentially following efforts for elimination of possible risks. In such conditions the goal is to develop the new vision on leadership and management in safety, security and defence areas, where the most critical processes could happen because of incorrect situation evaluation, both as the result of ignoring and/or overestimating the possible risks.

From the very beginning it has been a problem to identify what is mentioned by the word "risk", what this term stands for in safety and security areas. Plenty of definitions started from textual and ending with different formulas have being found (Fig. 2). One common element used in those definitions is "loss". Taking it as the start point and continuing to range around it as many connected elements as possible almost all corresponding areas have been covered. Taking in account that use of mathematic simulation will ask for clear definition of make-your-choice criteria, the Multi-criteria methods of reconciliation and evaluation of alternatives have been chosen and combined with human ability to percept and analyse information.

- Risk is the unwanted subset of a set of uncertain outcomes.

Cornelius Keating

- Risk is a Combination of the likelihood of an occurrence of a hazardous event or exposure(s) and the severity of injury or ill health that can be caused by the event or exposure(s).

OHSAS 18001:2007

- Risk – the quantifiable likelihood of loss or less-than-expected returns.

Wikipedia

$$\text{Risk} = (\text{probability of event occurring}) \times (\text{impact of event occuring}).$$

$$\text{Risk} = (\text{probability of an accident}) \times (\text{losses per accident}).$$

$$R(\theta, \delta(x)) = \int L(\theta, \delta(x)) f(x|\theta)\, dx$$

The risk function R of an estimator *δ(x)* for a parameter *θ*, calculated from some observables *x*, is defined as the expectation value of the loss function *L*,

Figure 3. Different risk interpretations

The fact that the decision-making process is not fully computerized and following conclusion that frequent involvement of external expert will be needed, as well as analysis of expert selection methods and phenomena of collective (group of experts) decision-making process emphasized the role of quality not only in process of risk detection and evaluation in decision-making but also in methods of selection of the experts involved in the decision-making.

As the result there were two main areas of the process of ensuring the quality of the risk determination by experts identified:

1. Determination and evaluation of the risk – area, which can be gradually formed to three sections:

Identification of alternatives of actions (using Theory of comparisons of alternative):

– Multi-criteria efficiency
– Analytical hierarchy
– Priority of significance

Selection/counting of the risks of alternative (separated by indication of…)

– Independency and self-sustainability
– Interconnectivity
– Multi-influential factors

Risk evaluation by use of:

– Statistic (known information)
– Mathematic (prognosis – unknown information)
– Analysis (known & unknown information + human intuition)

2. Selection of the experts – area, which covers two main interconnected sections, which can be shown separately only for visualization purpose:

Methods of selections of the experts:

– Specific professional competency or Professional variety (depends on object of expertise)
– Social diversity (depends on object of expertise)
– Free recruitment (depends on situation)

Assignation of the qualification of the experts:

– A priory:
  *documentary (external evaluation)
  *self-evaluation
  *cross-evaluation (by other experts in the same group)
– A posteriori:
  * test.

Finally, with concentration on the idea of ensuring the possible highest quality of such determination, possibly the most efficient way of selection of experts and determination of risks has been found. The quality of such expertise will be logically summarized from mathematically calculated quality of the risk evaluation accordingly estimated from four main elements:

- Risks detection accuracy
- Risk's factors identification
- Risk's factors measurement
- Integrated risk determination.

As well as mathematically calculated Credibility of Experts (group), which also must be estimated through "Assignation of the qualification of the experts" process, where each expert will be evaluated from the point of view of the following:

- Qualification
- Creativity
- Conformism
- Constructivism
- Criticism

- Attitude
- Aptitude
- Interoperability.

As a result of the analysis the algorithm of selection of experts and qualitative risk determination can be prepared for partial computerization of both processes. It can help significantly to create the effective risk determination and consequentially – provide qualitative decision-making.

References

1. ANSI/GEIA EIA-632, *Processes for Engineering a System*, Electronic Industries Alliance (EIA), Arlington, VA, September 2003.
2. Bowersox, Donald J., Closs, David J. *Logistical management. The integrated Supply Chain Process*, NY: The McGraw-Hill Companies, Inc.
3. Dreimanis,V. Some psychological aspects of military decision making. In: *Identifying the Personality of a Solder in the Science of Psychology – a Step Forward in the Future, Scientific Articles of the 45th International Applied Military Psychology Symposium, Latvia, Riga, 2009.* Riga, 2009.
4. Dreimanis,V. Logistical Leadership – the future management system of National Armed Forces. In: *90 anniversary of NAF, conference presentation materials, 2009.*
5. Dreimanis,V. Ensuring the Quality of Risk determination by experts in safety and security areas. In: *Baltic Defence Research and Technology Conference, 2009.*
6. Dreimanis,V., Melderis, J. *Lēmumu pieņemšanas procesa pamatojums uz daudzkritēriju risku analīzes bāzes, risinot drošības problēmas: Pārskats par zinātniski pētniecisko projektu, AZPC – 02/01.* Rīga, 2009.
7. Fishburn, P. *Utility Theory and Decision Making*. NY: Wiley, 1970.
8. Hertwig, R., Chase, V.M. Many Reasons or Just One: How Response Mode Affects Reasoning in the Conjunction Problem, *Thinking and Reasoning*, No 4, 1998.
9. Kahneman, D., Tversky, A. Prospect Theory: an Analysis of Decisions under Risk, *Econometrica,* No 47, 1979.
10. Kossiakoff, A., Sweet, W. *Systems Engineering: Principles and Practice*. Hoboken, NJ: John Wiley & Sons, 2003. ISBN 0471234435
11. Kruger, J., Dunning, D. Unskilled and Unaware of It: How Difficulties in Recognizing One's Own Incompetence Lead to Inflated Self-Assessments, *Journal of Personality and Social Psychology,* Vol. 77, No 6, 1999.
12. Larichev, O.I. Cognitive Validity in Design of Decision – Aiding Techniques, *J. Multicriteria Decision Analysis,* Vol.1, No 3. 1998.
13. Leach, R. *Introduction to Software Engineering*. Boca Raton, FL: CRC Press, 2000.
14. Montgomery, H., Svenson, O. *A think – aloud study of dominance structuring in decision processes. Process and Structure on Human Decision Making.* Chichester: J. Wiley and Sons, 1989.
15. Payne, D., Bettman, J., Coupey, E., Johnson, E. *A constructive process view of decision making: multiple strategies in judgment and choice in Psychological Decision Research*. North Holland, Amsterdam, 1993.
16. Philips, L.D. *Theory of Requisite Decision Models / K. Borcherding, B. Brehmer: Research perspectives on Decision Making under Uncertainty.* North Holland, Amsterdam, 1984.
17. Альгин, А.П. *Риск и его роль в общественной жизни* М.: Мысль, 1989.
18. Белешев, С.Д., Гурвич, Ф.Г. *Математико-статистические методы экспертных оценок,* Москва: Статистика, 1980.
19. Ларичев, О.И., Мечитов, А.И., Мошкович, Е.М. *Выявление экспертных знаний*. М.: Наука, 1989.
20. Миркин, Б. Г. *Проблема группового выбора*. М.: Наука. 1974.
21. Нейман, Дж., Моргенштерн, О. *Теория игр - экономическое поведение*. М.: Наука, 1970.
22. Хохлов, Н.В. *Управление риском*. М.: Изд. Юнити-дана, 1999.

Transport and Telecommunication, 2009, Volume 10, No 4
Transport and Telecommunication Institute, Lomonosov 1, Riga, LV-1019, Latvia

Authors' index

CUMULATIVE INDEX

TRANSPORT and TELECOMMUNICATION, Volume 10, No 4, 2009
(Abstracts)

Palšaitis, R., Petraška, A. Present Situation of Heavy Goods Traffic in Lithuania. *Transport and Telecommunication*, Vol. 10, No 4, 2009, pp. 4–7.

The article describes the heavy goods transportation situation in Lithuania. The emphasis is placed to determine the reasons which cause the problems of heavy goods transportation. Shippers and the transport companies which are organizing heavy goods transportation confront with the shortage of especial vehicles and handling equipment, high cost of transportation, high charges, imperfect legal base and awkward behaviour and bureaucracy of governmental institutions.

Keywords: heavy goods, transportation, costs, transportation environment

Pavlyuk, D. Spatial Competition Pressure as a Factor of European Airports' Efficiency. *Transport and Telecommunication*, Vol. 10, No 4, 2009, pp. 8–17.

This study deals with estimation of European airports' efficiency values and their interrelation with a level of competition pressure for passengers among airports.

In this paper a new adaptive definition of airport's catchment area is presented. Using this definition we develop an indicator of a level of competition pressure, based on overlapping of airport's potential catchment areas.

A stochastic frontier model to estimate efficiencies of airports is applied. The method includes the construction of a production frontier for a sample of airports and estimation of individual airports' efficiency values as distances from this frontier. A classic production approach to airport activities where an airport enterprise uses labour resources (a number of employees) and infrastructure (a number of runways, gates, check-ins and parking spaces) for transportation of passengers is discussed. A re-sampling jack-knife technique to test the reliability of airports' efficiencies estimates is used as well.

A relationship between a level of competition pressure and airports' operation efficiencies in case of imperfect spatial competition for passengers has been investigated.

Keywords: stochastic frontier, efficiency, airport, spatial competition

Siperkovskis, V. Using T.Saaty Method in Transport Systems Planning. *Transport and Telecommunication*, Vol. 10, No 4, 2009, pp. 18–27.

A transport system of a country meets the needs of individuals and enterprises located in its territory in transportation and related services. On the one hand it depends on the level of the development of state economy; on the other hand the transport system's development itself influences the GDP of the specific regions and the whole country. Transport system's development planning requires the systematic approach and the use of the indicators, which take into account its influence on the society's welfare. The pairwise comparison method introduced by Thomas L. Saaty meets the requirement of the systematic approach. The procedure of the analytic hierarchy process used in this method allows a group of people to co-operate on the particular problem, to modify the individual judgments and as a result to combine the group judgments according to the basic criterion. Two objectives are followed when working on the given subject: the demonstration of the opportunity of analytic hierarchy process' (AHP) use in estimation of the transport systems' investment influence on the Latvian society's welfare and assessing the opportunity of implementation of AHP algorithm using a standard Microsoft Office package and applying it to 5-6 level hierarchies and matrices that have up to 15 columns and lines.

Keywords: transport system, decision support methods, analytic hierarchy process, analytical planning

Tuenbaeva, A.N,. Nazarov, A.A. Investigation of Mathematical Model of Communication Network with Unsteady Flow of Requests. *Transport and Telecommunication*, Vol. 10, No 4, 2009, pp. 28–34.

When choosing structures and characteristics of computer networks in practice, frequently priority is given to the classical techniques and decisions. However, a closer research and disclosure of potential opportunities of networks of data transmission, is promoted by carrying out mathematical modeling.

In this work, mathematical models of computer networks of casual access in the form of mass service systems with a source of repeated calls and the notification about the conflict are constructed. A modified method of asymptotic analysis to investigate mathematical models of casual access network was developed.

The practical value of the work consists in the results of scientific research to promote carrying out a complex analysis, an optimization and a disclosing of potential opportunities of telecommunication systems of data transmission.

Keywords: random access, unsteady flow, asymptotic analysis

Vishnevsky, V., Zhelezov, R. Algorithm to Find the Shortest Path on a High-Dimensional Graph and Its Application for Timetable Information Systems. *Transport and Telecommunication*, Vol. 10, No 4, 2009, pp. 35–41.

We present architecture of a developed timetable information system and describe an original algorithm to find an optimal travel route on public transport.

Keywords: timetable information system, public transport, optimal travel route

Dreimanis, V. Decision-Making in Closed System Environment on the Base of Risk Determination, Like a Part of Logistical Leadership. *Transport and Telecommunication*, Vol. 10, No 4, 2009, pp. 42–49.

One of the most typical representatives of closed systems is the military system. Furthermore, the military decision-making process is based on standard procedures that from the one side make the process more simple and achievable, bet from the other side – dogmatic and too structured, so necessity of changing it to more flexible and based on considerable achievements in logistic, leadership, telematics and computing sciences – became obvious. The historic fact is, that logistic as such is the result and consequence of ancient development of the theory of war or in other words – military science. Thus, looking at development of logistic up to scientific acknowledgment, it is the time to recognize that the modern logistic is not only some transportation and delivering services providing system, which need to be managed, but it is also separate self-regulating management, development, information and analyses system, that can be again obtained like the “Art of manoeuvring of troops” (Theoretist of French military science Jominie, XIX century, CE). The idea is to introduce Logistical Leadership (not equal to Logistical or Logistics management) like an administration system based on logistical science achievements that cross-integrates self-management, self-development, information analysis and decision-making processes and provides the profit of the most qualitative decisions in any applying area.

The main component of any management system is the decision-maker. More explicitly – his/her ability to understand the interaction of all three components of decision-making triangle is situation, resources (available tools), and human’s/decision-maker’s potentials. The hypothesis that the first two elements have no influence from the decision maker’s side before a decision is made and a relative action taken concentrates our attention on the third one – a human. That approach has to be based not only on a creatively thinking individual, but also on scientifically approved methods of situation evaluation and risk analysis that have to be taken in use. Subsequently, we are finding ourselves in front of the task to create and optimise necessary tools and mathematic models that will allow to make correct choice of experts and to conduct qualitative analysis of information and risks, resulting with the most profitable, effective and faultless decisions – the target and the main product of an administration’s system – Logistical Leadership.

Keywords: logistic management, decision-making, standard procedures, risk management

TRANSPORT and TELECOMMUNICATION, 10.sējums, Nr.4, 2009 *(Anotācijas)*

Palšaitis, R., Petraška, A. Pašreizējā situācija Lietuvā smago kravu pārvadājumos. *TRANSPORT and TELECOMMUNICATION,* 10.sēj., Nr.4, 2009, 4.–7. lpp.

Rakstā tiek analizēta pašreizējā situācija Lietuvā smago kravu pārvadājumos. Uzsvars tiek likts uz cēloņu noteikšanu, kas rada problēmas smago kravu pārvadājumos. Kravas nosūtītājs un transporta kompānijas, kuras organizē smago kravu pārvadājumus, sastopas ar speciālā transporta līdzekļu un iekraušanas iekārtu trūkumu, augstām transportēšanas izmaksām, augstām cenām, nepabeigtu likumdošanu un savādu valdības institūciju birokrātijas uzvedību.

Atslēgvārdi: smagā krava, transportēšana, izmaksas, transportēšanas vide

Pavļuks, D. Telpisku konkursu spiediens kā Eiropas lidostu efektivitātes faktors. *TRANSPORT and TELECOMMUNICATION,* 10.sēj., Nr.4, 2009, 8.–17. lpp.

Autors šajā rakstā izpēta Eiropas lidostu efektivitātes vērtības un to savstarpējo saistību ar konkursu tiekšanās pēc pasažieriem līmeni starp lidostām.

Autors savā rakstā sniedz jaunu adaptīvo definīciju lidostas mikrorajonam. Lietojot šo definīciju, tiek attīstīts rādītājs konkursa spiediena līmenim, kas pamatots uz lidostu potenciālo mikrorajonu daļēju sakritību. Tiek pielietots stohastiskais robežas modelis, lai izvērtētu lidostu efektivitāti. Modelis iekļauj robežas pagarinājuma konstruēšanu lidostas piemēram un individuālo lidostu efektivitātes vērtības kā distances no šīs robežas novērtēšanu. Klasiskā pagarinājuma pieeja lidostas aktivitātēm, kur lidostas uzņēmums lieto darba resursus (nodarbināto skaits) un infrastruktūra (skrejceļu skaits, ejas, kontrolpunkti, un stāvlaukumi) pasažieru transportēšanai tiek diskutēti dotajā rakstā.

Bez tam rakstā tiek izskatīt arī konkursa spiediena līmenis un lidostas darbības efektivitātes attiecība nepilnīga telpiska konkursa tiekšanās pēc pasažieriem gadījumā.

Atslēgvārdi: stohastiskā robeža, efektivitāte, lidosta, telpisks konkurss

Siperkovskis, V. T.Saati metodes izmantošana transporta sistēmas plānošanā. *TRANSPORT and TELECOMMUNICATION,* 10.sēj., Nr.4, 2009, 18.–27. lpp.

Valsts transporta sistēma sastopas ar indivīdu un uzņēmumu nepieciešamību izmantot transporta pakalpojumus un ar to saistīto servisu. No vienas puses, tas ir atkarīgs no valsts ekonomikas attīstības līmeņa, no otras puses, transporta sistēmas attīstība pati par sevi ietekmē atsevišķu reģionu, kā arī visas valsts iekšzemes kopproduktu (IKP). Transporta sistēmas attīstības plānošana prasa sistemātisku pieeju un rādītāju izmantošanu, kuri ņem vērā tā ietekmi uz sabiedrības labklājību. Pāru salīdzināšanas metode, ko ieviesa Tomass L. Saati, atbilst sistemātiskās pieejas prasībām. Analītiskās hierarhijas procesa procedūra, kas tiek lietota šajā metodē, pieļauj cilvēku grupai kopīgi strādāt ar konkrēto problēmu, modificēt atsevišķus vērtējumus atbilstoši ar pamata kritērijam. Divi mērķi tiek sasniegti, strādājot ar šo uzdevumu: iespēju demonstrācija analītiskās hierarhijas procesa pielietošanā transporta sistēmas investīciju ietekmes uz Latvijas sabiedrības labklājību izvērtēšanā un analītiskās hierarhijas procesa ieviešanas iespējā, pielietojot standarta Microsoft Office paketi un piemērojot to 5-6 hierarhijām un matricām, kurām ir līdz 15 kolonnas un līnijas.

Atslēgvārdi: transporta sistēma, lēmumu atbalsta metodes, analītiskās hierarhijas process, analītiskā plānošana

Tuenbajeva, A.N., Nazarovs, A.A. Sakaru tīkla matemātiskā modeļa izpēte pie nepastāvīgas ziņojumu plūsmas. *TRANSPORT and TELECOMMUNICATION,* 10.sēj., Nr.4, 2009, 28.–34. lpp.

Praksē, izvēloties datora tīklu īpašības un struktūras, bieži vien priekšroka tiek dota klasiskajām tehnikām un lēmumiem. Tomēr ciešāka izpēte un datu pārraides tīklu potenciālo iespēju atklāšana tiek veicināta ar matemātisko modelēšanu.

Šajā darbā tiek uzbūvēti datoru tīklu, kuriem ir gadījuma pieejas masu apkalpošanas sistēmas veidā ar atkārtotu izsaukumu avotu un paziņojumu par konfliktu, matemātiskie modeļi.

Darba praktiskā vērtība ir zinātnisko pētījumu rezultātos, lai sekmētu kompleksās analīzes tālāko izpēti, kā arī potenciālo iespēju optimizācija un atklāšana datu pārraides telekomunikāciju sistēmās.

Atslēgvārdi: nejauša pieeja, nepastāvīga plūsma, asimptotiskā analīze

Višņevskis, V., Žeļeznovs, R. Liela izmēra grafa īsākā ceļa atrašanas algoritms un tā pielietošana informācijas sistēmu grafikā. *TRANSPORT and TELECOMMUNICATION,* 10.sēj., Nr.4, 2009, 35.–41. lpp.

Raksta autori piedāvā izstrādātu informācijas sistēmas grafika arhitektūru un apraksta oriģinālu algoritmu, lai atrastu optimālu maršrutu ceļošanai ar sabiedrisko transportu.

Atslēgvārdi: informācijas sistēmas grafiks, sabiedriskais transports, optimālais ceļošanas maršruts

Dreimanis, V. Lēmumu pieņemšana slēgtas sistēmas vidē riska noteikšanas pamatā kā loģistiskas līderības daļa. *TRANSPORT and TELECOMMUNICATION,* 10.sēj., Nr.4, 2009, 42.–49. lpp.

Viena no tipiskākām slēgta tipa vadības sistēmām ir militārā. Militārā sistēmā izmantojamais lēmuma pieņemšanas process balstās uz standarta procedūrām, kuras, no vienas puses, vienkāršo un padara šo procesu par vieglāk apgūstamu, bet, no otras puses, – dogmatiskāku un pārāk stingi strukturētu, tāpēc arvien vairāk kļūst skaidra nepieciešamība mainīt un padarīt šo procesu pielāgojamāku un balstītu uz sasniegumiem loģistikas, līderības, telemātikas un datorzinātnē. Tas ir vēsturisks fakts, ka loģistika pati par sevi ir karadarbības teorijas (militāras zinātnes) attīstības ne tikai sasniegums, bet arī pēctecis. Ieskatoties loģistikas attīstības tendencēs līdz pat atsevišķai zinātnes nozarei, ir laiks atzīties, ka moderna loģistika vairs nav vienkārši transportēšanas un piegādes sistēma, ko nepieciešams regulēt, bet tā ir atsevišķa pašregulēšanās vadības, attīstības, informācijas apkopes un analīzes sistēma, kas var atjaunot savas pozīcijas kā militāra māksla – „Spēku manevrēšanas māksla” (Džomini, Francijas militārais teorētiķis, XIX gadsimts). Tāpēc šo rakstu ideja ir prezentēt loģistisko vadību (nejaukt ar loģistikas vadību), kā vadības/administrēšanas sistēmu, kas balstās uz loģistikas zinātnes sasniegumiem un savstarpēji integrē sistēmas pašregulēšanās/pašmenedžmenta, pašattīstības, informācijas analīzes un lēmuma pieņemšanas procesus, ar izdevību nodrošināt maksimālu lēmuma pieņemšanas kvalitāti jebkurā pielietošanas sfērā.

Jebkuras menedžmenta sistēmas pamata elements ir lēmuma pieņēmējs. Precīzāk runājot, viņa/viņas spējas saprast trīs lēmuma pieņemšanas „komponentu” – situācija, resursi un cilvēks (pats lēmuma pieņēmējs) – savstarpēju sasaiti. Hipotēze, ka pirmie divi „komponenti” netiks ietekmēti no lēmuma pieņēmēja puses līdz brīdim, kamēr lēmums nav pieņemts, koncentrē mūsu uzmanību uz trešo komponentu – cilvēku. Šeit jēdziens „cilvēks” aptver ne tikai paša cilvēka radošās spējas, bet arī zinātniski pamatotās situācijas novērtēšanas un riska analīzes metodes, kuras viņš pielieto. Tāpēc noslēgumā mēs esam uzdevuma priekšā izveidot un optimizēt nepieciešamus rīkus un matemātiskos modeļus, kuri ļautu veikt pamatotu ekspertu izvēli, nodrošinātu korektu situācijas/informācijas un risku analīzi, un novestu līdz izdevīgākajam, efektīvākajam un brīvam no kļūdām lēmumam, kas ir administrēšanas sistēmas (loģistiskās vadības) mērķis un pamatprodukts.

Atslēgvārdi: loģistikas vadība, lēmuma pieņemšana, standarta procedūra, riska vadība

TRANSPORT
&
TELECOMMUNICATION

ISSN 1407-6160 & ISSN 1407-6179 (on-line)

Host Organizations:
Transport and Telecommunication Institute, Latvia – Eugene Kopytov, Rector
Telematics and Logistics Institute, Latvia – Igor Kabashkin, Director

Supporting Organizations:
Latvian Transport Development and Education Association
Latvian Academy of Sciences
Latvian Operations Research Society
Telecommunication Association of Latvia
Latvian Academic Park

All articles are reviewed.
Articles can be presented in the journal in English.

EDITORIAL CORRESPONDENCE

Transporta un sakaru institūts (Transport and Telecommunication Institute)
Lomonosova iela 1, LV-1019, Riga, Latvia. Phone: (+371)67100594. Fax: (+371)67100535.
E-mail: kiv@tsi.lv, http:// www.tsi.lv

TRANSPORT and TELECOMMUNICATION, 2009, Vol. 10, No 4
ISSN 1407-6160
The journal of Transport and Telecommunication Institute (Riga, Latvia).
The journal is being published since 2000.

The papers published in Journal "Transport and Telecommunication" are included in
SCOPUS (since 2008, Vol. 9, No 1), **Elsevier Database**
www.info.scopus.com
www.elsevier.com

PREPARATION OF CAMERA-READY TYPESCRIPT: COMPUTER MODELLING AND NEW TECHNOLOGIES

1. In order to format your manuscript correctly, see the Page Layout Guideline for A4 (21 cm x 29,7 cm) paper size. Page Layout should be as follows: Top – 3 cm, Bottom – 3 cm, Left – 3 cm, Right – 3 cm.
2. Maximum length for the article is **10 pages**.
3. **Using of other Styles with the exception of Normal is not to be allowed!**
4. ***Articles*** should be Times New Roman typeface, single-spaced.
5. The article should include:
   - title;
   - author's name(s) and information (institution, city, country, the present address, phones, and e-mail addresses);
   - abstract (100-150 words);
   - keywords (max. 6);
   - introduction – clear explanation of the essence of the problem, previous work, purpose of the research and contribution;
   - description of the research;
   - conclusion section (this is mandatory) – should clearly indicate on the advantages, limitations and possible applications;
   - references.

   Attention! First name, last name, the title of the article, abstract and keywords must be submitted in the English and Latvian languages (in Latvian it is only for Latvian authors) as well as in the language of the original (when an article is written in different language).
6. The text should be in clear, concise English (or other declared language). Please be consistent in punctuation, abbreviations, spelling (***British English***), headings and the style of referencing.
7. ***The title of the article*** – 14 point, UPPERCASE, style Bold and centred.
8. ***Author's names*** – centred, type size 12 point, Upper and lower case, style Bold Italic.
9. ***Author's information*** – 10 point, Upper and lower case, style Italic, centred.
10. ***Abstract and keywords*** – 8 point size, style Normal, alignment Justify.
11. ***The first level Headings*** – 11 point, Upper and lower case, style Bold, alignment Left. Use one line space before the first level Heading and one line space after the first level Heading.
12. ***The second level Headings*** – 10 point, Upper and lower case, style Bold, alignment Left. One line space should be used before the second level Heading and 1/2 line space after the second level Heading.
13. ***The third level Headings*** – 10 point, Upper and lower case, style Italic, alignment Left. One line space should be used before the second level Heading and 1/2 line space after the third level Heading.
14. ***Text*** of the article – 10 point, single-spaced, alignment Justify.
15. The set of ***formulas*** on application of fonts, signs and a way of design should be uniform throughout the text. The set of formulas is carried out with use of editors of formulas MS Equation 3.0 or MathType. The formula with a number – the formula itself should be located on the left edge of the text, but a number – on the right one. Font sizes for equations are the following: 11pt – full, 7pt – subscripts/superscripts, 5pt – sub- subscripts/superscripts, 16pt – symbols, 11pt – subsymbols.
16. All ***Figures*** – must be centred. Figure number and caption always appear below the Figure, type size 8 point.

Figure 1. This is figure caption

Diagrams, Figures and Photographs – must be of high quality, in format *.TIFF, *.JPG, *.BMP with resolution not less than 300 dpi. Also formats *.CDR, *.PSD are possible. Combination of Figures in format, for instance, *.TIFF with elements of the in-built Figure Editor in MS Word is prohibited.

17. ***Table Number and Title*** – always appear above the Table. Alignment Left. Type size 8 point. Use one line space before the Table Title, one line space after the Table Title and 1/2 line space after the Table.

Table 1. This is an example of a Table

Heading	**Heading**	**Heading**
Text	Text	Text
Text	Text	Text

18. ***References*** in the text should be indicated by a number in square brackets, e.g. [1].
References should be numbered in the order cited in the manuscript. The correct format for references is the following:

*Article***:** author, title, journal (in italics), volume and issue number, year, inclusive pages
Example: 1. Amrahamsson M., Wandel S. A Model of Tearing in Third – Party Logistics with a Service Parts Distribution Case Study, *Transport Logistics*, Vol. 1, No 3, 1998, pp. 181-194.

*Book***:** author, title (in Italics), location of publishers, publishers, year, whole pages
Example: 2. Kayston M. and Fried W. R. *Avionic Navigation Systems.* New York: John Wiley and Sons Inc, 1969. 356 p.

Conference Proceedings: author; title of an article; proceedings (in italics); title of a conference, date and place of a conference; publishing house, year, concrete pages
Example: 3. Canales Romero J. A First Step to Consolidate the European Association of Aerospace Students in Latvia (Presented by the Munich Local Group). In: *Research and Technology – Step into the Future: Programme and Abstracts. Research and Academic Conference, Riga, Latvia, April 7–11, 2003, Transport and Telecommunication Institute.* Riga: TTI, 2003, p. 20.

19. ***Authors Index***
Editors form the author's index of a whole Volume. Thus, all contributors are expected to present personal colour photos with the short information on the education, scientific titles and activities.
20. ***Acknowledgements***
Acknowledgements (if present) mention some specialists, grants and foundations connected with the presented paper. The first page of the contribution should start on page 1 (right-hand, upper, without computer page numbering). Please paginate the contributions, in the order they are to be published. Use simple pencil only.
21. **Articles poorly produced or incorrectly formatted may not be included in the proceedings**.