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STUDY PROGRAMMES IN TRANSPORT ENGINEERING AND TELECOMMUNICATION ENGINEERING: ATTRACTIVENESS AMONG APPLICANTS TO LITHUANIAN UNIVERSITIES

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The operation of industrial, construction and agricultural enterprises as well as work efficiency and public opinion largely depends on reliability and effective performance of transport and telecommunication. The qualified specialists of Lithuanian universities educated in transport engineering and telecommunication engineering are highly appraised in the European Union countries and others countries. The present paper deals with the higher education system of Lithuania, also describes a system of joint admission to Lithuanian higher schools, which is being already used for several years in this country. The problems of selecting applicants to the Lithuanian universities and the level of knowledge of the applicants admitted to study the programmes in transport engineering and telecommunication engineering, and other study programmes are also discussed in the present paper.

Keywords: *Lithuanian higher schools, universities, higher education, applicants, joint admission, transport engineering, telecommunication engineering, study programmes, popularity, competitiveness index, motivation index*

1. Introduction

Modern society places a particular emphasis on technological and social sciences because no state can prosper without having a sufficient amount of highly qualified specialists in technologies, economics and management. The demand for specialists in technological and social sciences, their competitiveness in the labour market, prestige and payment as well as popularity of these specialities with school-leavers have been changing considerably during the seventeen years of Lithuanian independence.

When Lithuania joined the European Union, transport and telecommunication became the most important branches of national economy. Now, the economic development is hardly possible without an effective transport system (providing both local and international transportation) and quality telecommunication system (providing communication within and between the countries). The operation of industrial, construction and agricultural enterprises as well as work efficiency and public opinion largely depend on reliability and effective performance of transport and telecommunication systems [1–5].

The study programmes of social science are still most popular with young people, however, technological sciences are ranked the second, and this is already a trend. Therefore, the present paper considers these significant problems.

The attitude of young people to engineering study programmes is getting more positive. The results of the last year admission to our university (Vilnius Gediminas Technical University) and others Lithuanian universities show the tendency for applicants to have higher competitive marks to be enrolled [6, 7].

2. Transport and Telecommunication – Most Important Branches of Country Economics

Transport and telecommunication are the key branches of economy. The development of economy can hardly be imagined without transport and telecommunication now. The reliable and well organized transport and telecommunication services are required for efficient performance of industry, construction and agriculture. General feeling and the efficiency of people’s work also largely depend on transport and telecommunication systems and their performance. Therefore, satisfying the demand of people for timely provided quality transport and telecommunication services is becoming a social, rather than a merely transport and telecommunication problem, determining the attitude of citizens not only to the level of the provided services, but to all processes, taking place in a particular state as well.

Increasingly growing transportation by motor vehicles is accompanied by increasing demands for higher quality of transport services and higher efficiency of transport performance. Harmonized development of state economy requires that more attention be paid to the problems of organization and management of automobile transport by all engaged in providing transport services. This, in turn, requires more effective planning as well as the analysis and evaluation of various economic aspects of the performance of large transport systems and individual motor vehicles. Precise calculation and analysis are key factors in developing rational schemes of energy-efficient freight transportation. Effective economic solutions make a basis for successful development of transport enterprises, ensuring their profitable work. Transportation mainly relies on vehicles, which are becoming more and more complicated, as far as their design, structures and operation principles are concerned. One of the main tasks of transport is to increase the amount of the transported goods and to ensure traffic safety. The operation of transport facilities largely depends on many factors. Most of them have a negative effect on transport performance, e.g. poor roads, inefficient organization of road traffic, poor technical state of transport facilities, bad weather or visibility, high density of traffic flows, the choice of inappropriate motor vehicle speed, etc.

Technical and technological advance, as well as the development of new information and telecommunication technologies, brought about great changes in our lifestyle and required new approaches to work. Today, small-size powerful electronic devices can often change a number of staff members in the company, while its office may be held in a briefcase. Therefore, it is clear that, in the near future, the equipment needed for works will be miniaturized so that it could be carried on a belt. Wide-spread mobile phones and pagers are living proof of it. Quite recently, great distances between dwellings and workplaces of employees prevented them from achieving high labour productivity. However, later this obstacle has been removed due to great advances in telecommunication. Work efficiency of people is no longer dependent on their location because they can efficiently work everywhere – at home, in the office and even in a trip. Computers, modems, electronic mail and the Internet allow office workers and businessmen to communicate with their colleagues, exchange data with the web-server of the company, follow the dynamics of stock-exchange and send faxes to customers. All these operations can be performed at any place where they are at the moment. At the end of the 20-th century, many companies experienced its strong influence on the methods of work organization and management and began searching for new approaches to raising their competitiveness. Hundreds of managers and vendors realized that precious time can be spent more effectively by making contracts and deals with the clients at a distance, rather than travelling to workplaces. Since that time, information and telecommunication technologies have been increasingly developed to satisfy the demands of the world market in compliance with the new trends of its development, and the achievements in these areas are impressive.

3. Lithuanian Higher Education System

In 1989, a discussion about the introduction of two-stage education, involving Bachelor's and Master's degree studies, was organized. In 1991, the law was adopted on science and education in the Republic of Lithuania, legitimating the reform made in this area. Since then this system has been considerably improved, and the 3rd stage of Doctoral studies was introduced [6, 7]. Beside Bachelor's and Master's studies, there is a system of two-stage professional training aimed at more practical aspects of education. The scheme of Lithuanian higher education system is presented in Figure 1.

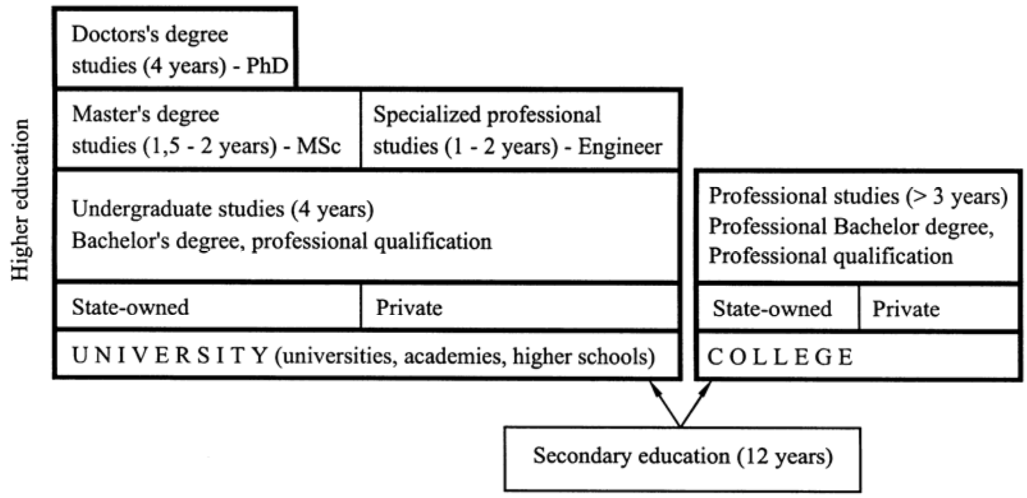

Figure 1. *Scheme of Lithuanian higher education system*

There are two types of higher schools in Lithuania, providing:

- university-level education (universities and academies);
- non-university-level education (colleges).

The graduates of the 1st type institutions are awarded diplomas, certifying about higher university-level education and the Bachelor's degree, while the graduates of the 2nd type schools get diplomas, certifying about non-university-level education and a particular qualification. Since 2007 graduates of colleges will get Professional Bachelor's degree.

The state finances the acquisition of higher education at full-time department once both at universities and non-university institutions (while not financing part-time learning – evening or extra-mural). Therefore, to continue studies, school-leavers should choose either a university providing three-stage education (for Bachelor's, Master's and Doctor's degrees) or a non-university school aiming at a particular qualification. The graduates of non-university higher school, applying to a university higher school for obtaining a Master's degree, should take the first stage study programme at a university higher school, since they do not have a Bachelor's degree.

4. The Criteria of Selecting Applicants to Lithuanian Higher Schools

The applicants to Lithuanian higher schools are admitted basing on their competitive marks calculated for each study programme mentioned in each application. The competitive marks are calculated for particular study programmes, according to the standing rules of particular higher schools. School-leavers can include up to 20 study programmes in their applications [1, 4–7].

In fact, there are no entrance examinations in Lithuanian higher schools. They should be taken only by the applicants to some specific study programmes, such as architecture, arts, design, fire prevention, etc. As a rule, the exams should be just passed (without any marks), however, if an entrance examination is assessed in points, then, the estimate of the test makes about 50 % of the total competitive mark for a particular study programme.

The first step to simplify the admission to higher schools is making the requirements to school-leaving exams more rigorous. Then, the National Examination Centre [8] is established for administrating and supervising the state school-leaving exams. When school-leavers pass these exams well, their chances to be admitted to higher schools increase (because a few additional points are given to them, see Table 1).

In Lithuania, school-leaving examinations and the overall marks in school-leaving certificates are of several types and levels [1, 4–9].

The examination and overall marks are converted into a common system of marks, when establishing competitive marks for all specialities in all higher schools of Lithuania involved in the joint admission programme (see Table 1) [1, 5–7]. As it is shown in Table 1, it is more advantageous for a school-leaver to take state final exams and to have an overall mark for a special subject because he/she will get many additional points for them, when the marks will be recalculated according to a common system of marking.

Table 1. Recalculation of examination and overall marks taken from school-leaving certificates of school-leavers into a common system of marking

Marks from school-leaving certificate			Recalculated mark according to a common system of marks
Examination	State final examination (Est)	100-point evaluation system	Est / 10 + 13
	School-leaving examination (Esl)	10-point evaluation system	Esl + 3
	School-leaving examination at the level *S* or *A* (Ea)		Ea + 4
	School-leaving examination at the level *B* (Eb)		Eb + 3
Overall	Special course examination at the level *T* or *S* (Ot)		Ot + 2
	Complete course examination at the level *A* (Oa)		Oa + 1
	General course examination at the level *B* (Ob)		Ob + 0

5. Joint Applicants' Admission to Lithuanian Higher Schools

The Lithuanian higher schools formed an Association of Lithuanian Higher Education Institutions to implement the programme of joint admission [5–7, 9] helping the applicants to enter a higher school and to reduce the risk of a single possible choice, as well as making the selection of potential students more objective and simplifying the entrance by allowing them to apply to several higher schools simultaneously. Based on this programme, an applicant is given an opportunity to choose a higher school and a study programme according to his/her order of preference and depending on the marks obtained in a secondary school. An applicant submits an application to any of the higher schools of the Association, allowing him/her to select a number of study programmes in several higher schools [5–7, 9, 10].

Seventeen university-level higher schools and two non-university-level higher schools formed the Association [5, 6, 9] (sixteen higher schools are state-owned and three higher schools are private): General Jonas Žemaitis Military Academy of Lithuania (LKA), International Business School at Vilnius University (VU TVM), Kaunas University of Medicine (KMU), Kaunas University of Technology (KTU), Klaipėda University (KU), Lithuanian Academy of Music and Theatre (LMTA), Lithuanian Academy of Physical Education (LKKA), Lithuanian University of Agriculture (LŽŪU), Lithuanian Veterinary Academy (LVA), Mykolas Romeris University (MRU), Šiauliai University (ŠU), University of Management and Economics (ISM), Vilnius Academy of Fine Arts (VDA), Vilnius College of Higher Education (VK), Vilnius Gediminas Technical University (VGTU), Vilnius Law and Business College (VTVK), Vilnius Pedagogical University (VPU), Vilnius University (VU), Vytautas Magnus University (VDU).

In 2007, the Lithuanian higher schools participating in joint applicants' admission programme offered the applicants 1057 study programmes: full-time (daytime) studies, part-time (evening) studies, part-time (extra-mural) studies in 62 study fields, which make 6 groups of study areas: technological sciences, social sciences, physical sciences, biomedicine sciences, humanities and fine arts.

A general chart of joint applicants' admission to Lithuanian higher schools is presented in [5–7]. The main parts of them are the following:

- start of joint applicants' admission (April 13, 2007) – accepting applications to Lithuanian higher schools from applicants (via Internet and personally);
- carrying on entrance examinations;
- correcting the study programmes indicated in the application (if requested by an applicant);
- accepting and considering applicants' appeals for correcting errors in evaluating examinations;
- registering the documents;
- announcing the competitive marks of applicants;
- accepting and considering applicants' appeals for correcting errors in calculating competitive marks;
- announcing the lists of applicants admitted to higher schools for all available study programmes;
- officially registering the admission of applicants to particular higher schools;
- completing of joint applicants' admission (August 2, 2007) – announcing the information about vacancies left.

An applicant, participating in the joint admission programme, can mention up to twenty study programmes (choices) in the application to study at any Lithuanian higher schools. Study programmes are arranged in the order of preferences in the application. The name of the higher school, form of studies and financing are indicated for every study programme [1, 5–7, 9,10]. The applicant is admitted to a higher school to study one of the study programmes included in his/her application, which is determined by computer after calculating his/her competitive mark. When the first study programme from the list of applicant's preferences is found, for which the calculated competitive mark satisfies the requirements of admission, all other study programmes given below in the list are not considered (though the mark is sufficient for an applicant to be admitted to study them).

6. Study Programmes in Transport Engineering and Telecommunication Engineering at Lithuanian Universities

Four of the above-mentioned higher schools offer study programmes in transport engineering and telecommunication engineering, leading to Bachelor's degree (qualifications: Bachelor of Transport Engineering or Bachelor of Electronic Engineering) [1, 5, 6, 9]. They are as follows: Vilnius Gediminas Technical University, Kaunas University of Technology, Klaipėda University, Vilnius University.

Figure 2 presents a map of Lithuania showing the location of these universities and the available study programmes in transport engineering and telecommunication engineering belonging to the field of technological sciences.

Much more students are admitted to full-time studies of transport engineering and telecommunication engineering than to part-time studies and distant learning. Further, the data on the selection of applicants to full-time studies will be analysed [1, 10].

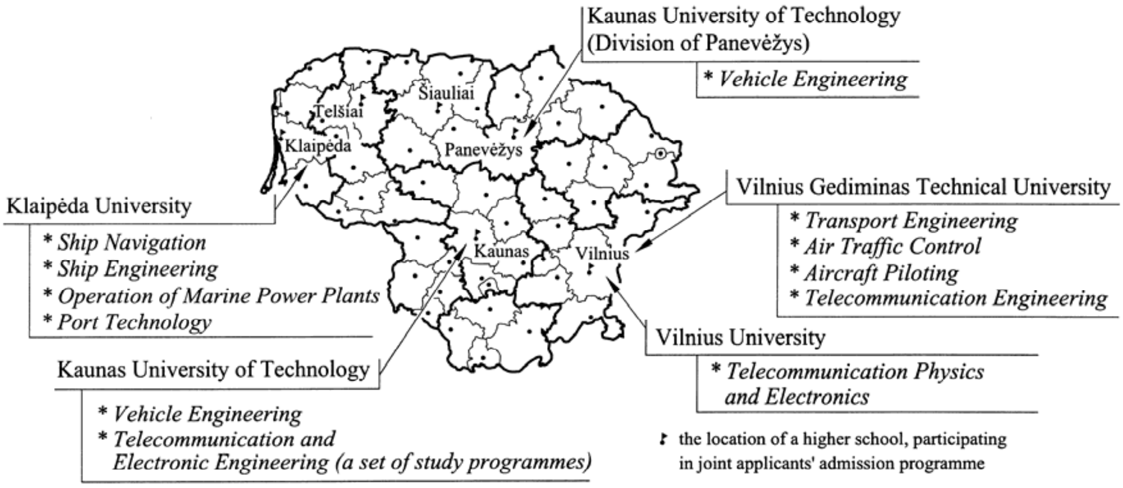

Figure 2. *A map of Lithuania, showing the location of universities providing study programmes in transport engineering and telecommunication engineering in 2007*

Competitive marks [1, 5, 6, 9] of the applicants to study according to the programmes in transport engineering and telecommunication engineering at various Lithuanian universities are presented in Table 2.

Table 2. Competitive marks of applicants to study according to the study programmes in transport engineering and telecommunication engineering at Lithuanian universities in 2007

Examination mark at school	Weighted coefficient	A yearly mark in school-leaving certificate	Weighted coefficient
Vilnius Gediminas Technical University: *Transport Engineering* – Bachelor of Transport Engineering *Air Traffic Control* – Bachelor of Transport Engineering *Aircraft Piloting* – Bachelor of Transport Engineering *Telecommunication Engineering* – Bachelor of Electronic Engineering			
mathematics	0,50	a foreign language	0,15
the Lithuanian language	0,20		
physics	0,15		
Kaunas University of Technology: *Vehicle Engineering* – Bachelor of Transport Engineering *Telecommunication and Electronic Engineering (a set of study programmes)* – Bachelor of Electronic Engineering			
mathematics	0,50		
the Lithuanian language	0,20		
physics	0,20		
a foreign language	0,10		
Klaipėda University: *Ship Engineering* – Bachelor of Transport Engineering *Port Technology* – Bachelor of Transport Engineering			
mathematics	0,38	mathematics	0,17
physics or information technologies	0,25	physics or information technologies	0,10
a foreign language	0,06	a foreign language	0,04
Klaipėda University: *Ship Navigation* – Bachelor of Transport Engineering *Operation of Marine Power Plants* – Bachelor of Transport Engineering			
mathematics	0,33	mathematics	0,12
physics	0,25	physics	0,10
a foreign language	0,15	a foreign language	0,05
Vilnius University: *Telecommunication Physics and Electronics* – Bachelor of Electronics Engineering			
physics	50,00	a foreign language	9,00
mathematics	25,00	physics	4,00
the Lithuanian language	7,00	mathematics	3,00
		the Lithuanian language	2,00

7. Popularity of Study Programmes with the Applicants, Participating in Joint Admission to Lithuanian Higher Schools in 2007

Study programmes in transport engineering and in telecommunication engineering – are study programmes in technological science.

Twenty most popular study programmes, based on the analysis of all applications submitted by school-leavers to study at Lithuanian higher schools according to joint admission programme are given in Table 3 [10]. Study programme in technological science among the top twenty most popular specialities are shown in grey colour in Table 3.

Twenty most popular study programmes in technological science, based on the analysis of all applications submitted by school-leavers to study at Lithuanian higher schools according to joint admission programme are given in Table 4 [10]. Some of the considered study programmes in transport engineering and telecommunication engineering among the top twenty most popular specialities are shown in grey colour in Table 4.

Table 3. Most popular study programmes in 2007 according to the number of applicants' choices

No	Higher school	Study programme	Number of choices
1	MRU	Public Administration	3050
2	VK	Tourism and Hotel Administration *(non-university-level study programme)*	3023
3	VGTU	Business Management	2975
4	VU	Management and Business Administration	2861
5	VGTU	Real Estate Management	2860
6	VGTU	Office Management	2754
7	VK	Advertising Management *(non-university-level study programme)*	2682
8	VK	Business Management *(non-university-level study programme)*	2549
9	MRU	Law and Management	2384
10	MRU	Financial Economics	2358
11	VK	Banking *(non-university-level study programme)*	2123
12	MRU	Law	2101
13	VU	Economics	2074
14	VU	Business Information Management	2064
15	VGTU	Construction Engineering	2038
16	VK	Office and Enterprise Management *(non-university-level study programme)*	1962
17	KTU	Business Administration	1953
18	VU	Law	1872
19	VK	Insurance Management *(non-university-level study programme)*	1739
20	KTU	Management	1707

Table 4. Most popular study programmes in technological sciences in 2007 according to the number of applicants' choices

No	Higher school	Study programme	Number of choices
1	VGTU	Construction Engineering	2038
2	KTU	Civil Engineering	1514
3	VGTU	Transport Engineering	1489
4	VGTU	Civil Engineering	1291
5	VGTU	Geodesy	1109
6	VGTU	Environmental Engineering	1109
7	VGTU	Industrial Engineering	1017
8	KTU	Telecommunication and Electronic Engineering	916
9	VGTU	Telecommunication Engineering	905
10	KTU	Automation, Control and Electrical Power Engineering	894
11	KTU	Mechanical Engineering	889
12	VGTU	Mechanical Engineering	791
13	KTU	Vehicle Engineering	780
14	KTU	Engineering Systems of Buildings	775
15	VGTU	Building Energetic	755
16	VGTU	Electronic Engineering	739
17	LŽŪU	Land Management	734
18	VGTU	Automation and Control	706
19	KTU	Environmental Engineering	694
20	VGTU	Computer Engineering	692

The popularity of particular sciences with school-leavers varies to a large extent (see Figure 3).

Study programmes in transport engineering and telecommunication engineering there are study programmes of technological sciences. The popularity of technological sciences (in 2002–2007) is demonstrated in Figure 4 [10].

Popularity of ten most popular university-level study programmes (five study programmes – from Table 3 and five study programmes – from Table 4) in (2002–2007) is demonstrated in Figure 5.

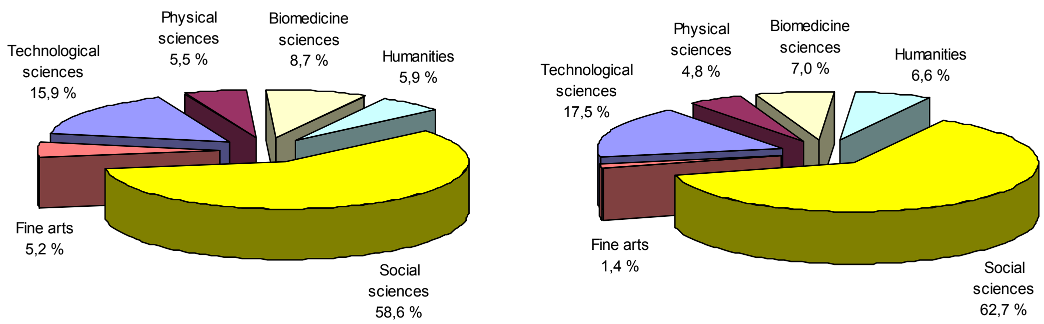

Figure 3. *Popularity of study programmes according to the study areas in school-leavers' applications in 2007: a – based on choice (study programme) No 1 in the application; b – based on all choices (study programmes) mentioned in the application*

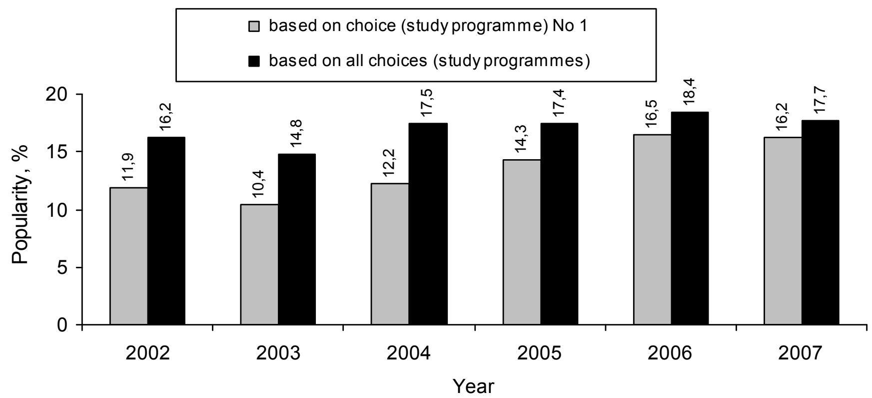

Figure 4. *Popularity of study programmes in technological sciences in 2002–2007, in per cent (the number of applicants to all study programmes is assumed to be equal to 100 %)*

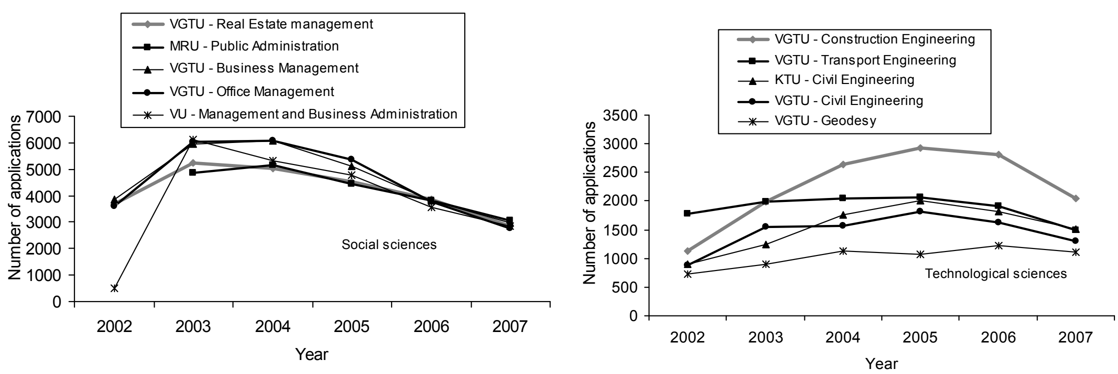

Figure 5. *Ten most popular university-level study programmes in 2002–2007*

The *competitiveness index* [1, 5] shows the preparation for studies and intellectual potential of the admitted to a particular study programme. It is calculated as the average mark of the key subjects in the school-leaving certificates of all admitted to study this programme.

The competitiveness index of the admitted to study a particular study programme is calculated in the following way:

$$I_c = \frac{\sum_{i=1}^{m}\left(\frac{LL+M+P+FL+H}{5}\right)_i}{m},$$

where: I_c is a competitiveness index of the admitted to a particular study programme; m is the number of the admitted to the study programme; LL is a mark for the Lithuanian language in school-leaving certificate; M is a mark for mathematics in school-leaving certificate; P is a mark for physics in school-leaving certificate; FL is a mark for a foreign language; H is a mark for history in school-leaving certificate.

To calculate I_c, a mark obtained at the secondary school-leaving state examination [1, 5, 6, 10] is considered. If this exam was not taken, the mark obtained at school-leaving examination is considered.

The competitiveness index shows the competitiveness of an applicant to study any programmes at a higher school (compared to other applicants). The higher the competitiveness index of a study programme, the higher the general level of education of a person admitted to study a particular programme.

The highest possible competitiveness index for the best applicant is equal to $I_c = 23$.

Competitiveness indices of full-time studies in transport engineering and telecommunication engineering university-level study programmes are given in Figure 6. As it is shown in the chart, more qualified applicants are admitted to the study programme in transport engineering – KU Port Technology, and in telecommunication engineering – VU Telecommunication Physics and Electronics.

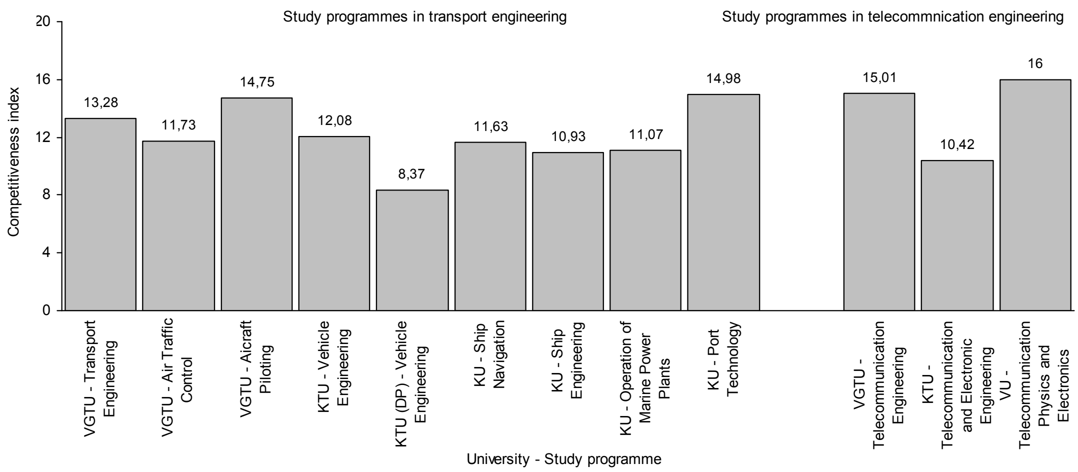

Figure 6. *Competitiveness indices of full-time studies in transport engineering and telecommunication engineering university-level study programmes in 2007*

Training of a qualified specialist depends not only on the number of qualified university teachers, well-equipped laboratories and training centres, but also on the thirst for knowledge and eagerness of an applicant to become a qualified specialist in the selected field, i.e. his/her motivation. Motivation is reflected by the order of preference given by an applicant to a particular study programme in the application to a higher school.

The *motivation index* [1, 5] is calculated by the formula:

$$I_m = \frac{\sum_{i=1}^{m} O_i}{m},$$

where: I_m is a motivation index of a particular study programme; O_i is the order of preference (No) given by the i-th applicant to a particular study programme; m is the number of applicants admitted to a particular study programme.

The lower the index value, the higher the motivation of applicants taking a particular study programme. The ideal motivation index is $I_m = 1$, when all school-leavers admitted to a particular study programme mention it in the application as choice No 1.

Motivation indexes of full-time studies in transport engineering and telecommunication engineering university-level study programmes are given in Figure 7. As it is shown in the chart, more highly motivated applicants are admitted to study programme in transport engineering – VGTU Aircraft Piloting, and in telecommunication engineering – VU Telecommunication Physics and Electronics.

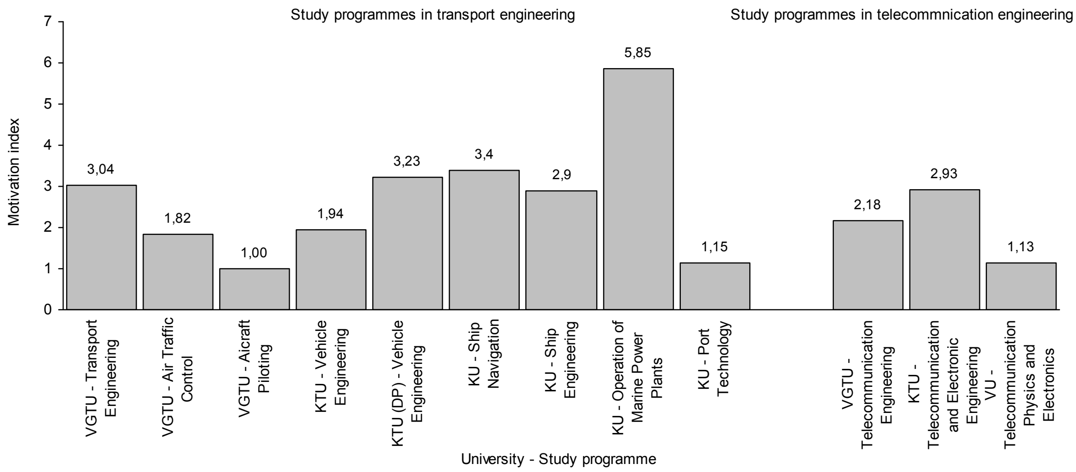

Figure 7. *Motivation indices of full-time studies in transport engineering and telecommunication engineering university-level study programmes in 2007*

8. Conclusions

1. The modern system of joint admission of school-leavers to Lithuanian higher schools (universities and colleges) described in the present paper facilitates the process of applicants' admission to higher schools, increases objectivity of potential students' selection, simplifies the formal procedure of admitting the applicants, allowing them to apply to several higher schools simultaneously, eliminates the risk of a single possible choice of speciality and higher school, and gives school-leavers time for relaxation before starting the studies at a higher school.
2. Nowadays, study programmes in social sciences are most popular among the applicants to Lithuanian higher schools.
3. Nowadays, study programmes in transport engineering and telecommunication engineering are most popular among programmes in technological sciences among the applicants to Lithuanian universities.
4. The educational level of the applicants and those admitted to take various study programmes can be defined by their competitive marks and competitiveness indices. The competitiveness index shows the preparation for studies and intellectual potential of applicant admitted to a particular study programme. Motivation is reflected by the order of preference given by an applicant to a particular study programme in the application for admission to a higher school.

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MACROECONOMIC REGULATION OF AIR TRANSPORTATION MARKET UNDER MODERN ECONOMIC CONDITIONS

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The article deals with modern problems of functioning of air transportation market. Macroeconomic regulation is considered as the factor having an essential influence on the state of air transportation market and the level of profitableness of modern airlines. Priority directions of macroeconomic regulation from the positions of providing of the functioning of effective air transportation market are determined. Possible state participation forms in airlines activity are analysed.

Within the limits of the article special attention is paid to the problems of state risk-management in the sphere of air transportation. Main macroeconomic risks, which are necessary to be considered in the limits of modern airlines risk- management, are determined.

"Human factor" importance in providing of the functioning of effective air transportation market including the provision of aircraft activity safety is underlined. The personnel motivation problems under "force-majeure" circumstances are considered and the necessity of state and private investors' participation in the formation of social guarantees to modern airline personnel is determined.

Keywords: *air transportation market, risk, risk-management, state regulation, profitableness, safety, personnel guarantee, motivation*

1. Introduction

Specific character of modern economic conditions leaves its mark on all the levels of world economy including the system of relations existing in air transportation sphere. This dynamic branch of world economy is subjected to the influence, in the first place, of institutional subjects. States, blocks of states and international organizations are meant.

In the main predestination macroeconomic regulation is aimed of anti cyclic influence on the economy of the country under the condition of activation of risky- forming factors in the world economy. The support of stable economic growth in the country is a super task. Real economic growth, guarantee stable money circulation in the country, rational and effective employment and, at last, effective interaction with world community are macroeconomic regulators' main problems. Air transportation market refers to most important markets in the world economy. As its element the air transportation market:

- uses common world air space;
- depends on the tendencies of development of the world economy;
- becomes more active under the condition of world economy internationalisation and consolidation of international cooperation;
- depends on market condition an main world market;
- it is greatly regulated by mega economic regulators.

In this connection the problem of institutional air transportation market regulation is actual factor and demands special consideration.

2. Modern Problems of Air Transportation Market

Investigations show that air transportation rate of development outstrips the level of business activity in the world. Thus within the period from 1985 to 2005 GDP (Gross Domestic Product) growth in the world was 3,7 %, but the volume of transportation growth in pass./km was 5,2 % [1].

Macroeconomic regulators should take into consideration main characteristics of modern air transportation market:

- high level of competition;
- high level of capital concentration and centralization of market participants;
- high level demands for securing safety in activity;
- uninterrupted implementation of capital investments;
- great influence of SRW and their implementation in market functioning;
- high level demands for personnel training and retraining process.

Macroeconomic regulators cannot avoid vivid tendency in world aviation. It is as follows:

1. Decrease of large network trunk airlines in number at the expense of their merging or bankruptcy.
2. Active appearance of low budget carriers carrying on aggressive commercial policy and forcing out network airlines from intra-regional and inter-regional lines [1].

Practice puts in the fore front the following problems:

1. Rational use of air space [2].
2. Necessity of joining producers' assets because disconnected carriers' assets are obstacles in air transport industry development [3].

Moreover ICAO points out that the countries consider air transport as a source of finance for different goals [1]. Specialists fix constant growth of air navigational duties without corresponding growth of service level; considerable financial airline expenses on aircraft certification [2]; great level of restrictions at purchasing foreign equipment etc [3]. All these positions indicate that macroeconomic air transportation market regulation demands improvement.

The results of large-scale world airline managers questioning which Sabre Airline Solutions carried out in spring 2007 confirm this [4]. The company managed to get the opinion of 197 managers from 101 world companies representing three regions with most intensive air transportations. North America was in the first region (62 men, 32% inquired); Europe, Middle East and Africa were included in the second region (72 men, 36% inquired); Asia and Latin America were included into the third region (63 men, 32%). Distribution of interrogated airlines according to their activity is given in Table 1.

Table 1. Distribution of interrogated carriers according to their business

Type of carrier	Share, %
Large US companies	9
International long-distance carriers	18
Traditional national carriers	25
Regional airlines	20
Low rate carriers	10
Companies with combined business models	18

Source: Sabre Airline Solutions [4].

We can state that research has become representative both from the geographical distribution at participants and from the point of view of interrogated carriers according to business character [4].

The answers to the question: "What factors exert influence upon the branch development?" are distributed in the following way (Figure 1).

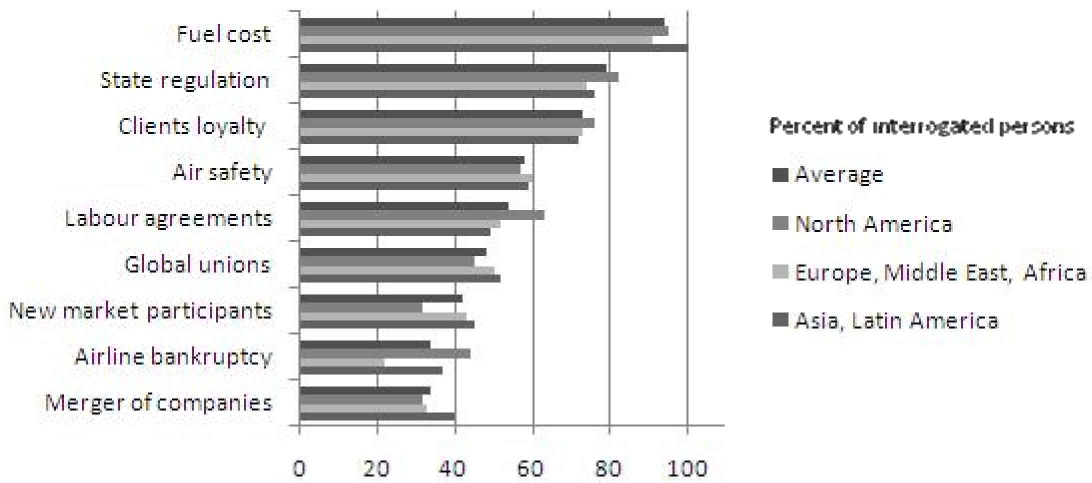


Figure 1. *What factors exert important influence on the branch development?*

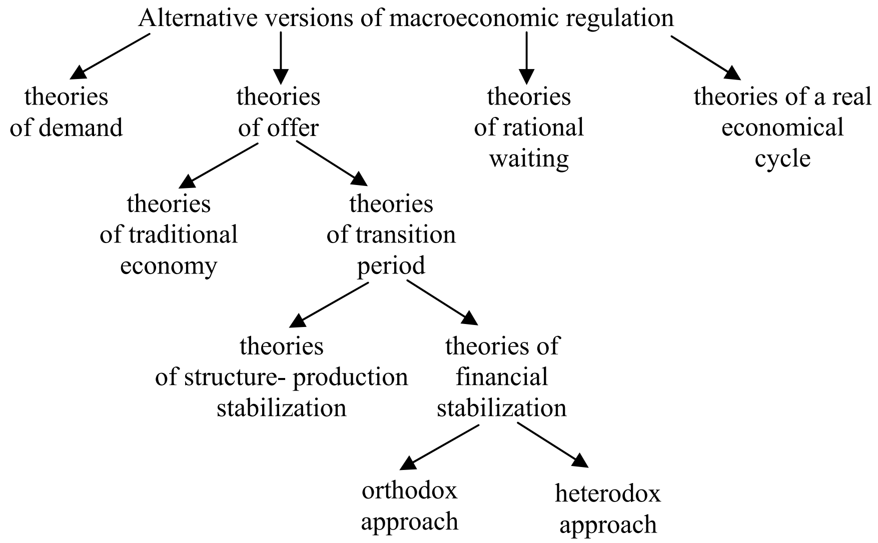
Source: Sabre Airline Solutions [4].

Fuel cost as most important factor of branch development was marked by 94 % of interrogated world airlines managers. The second factor by importance is state regulation of the carrier action (79 % respondents). 75 % of interrogated persons consider that the branch development depends on clients' loyalty. Aircraft safety questions were put on the third place in the list of factors exerting most important influence on the branch development [4].

In this case we point out that top-managers of leading airline put mega-economic factor on the first place, on the second place – the factor formed at macroeconomic level, the third place was given to mezzo-economic factor. Thus, the results of questioning indirectly confirm researcher's positions in the sphere of economic relations about the fact that under modern conditions the processes occurring on the level of state government, tendency in world economy development as a whole are of great importance for business development.

3. Directions and Forms of Macroeconomic Regulation

In any case, state regulation of macroeconomic processes must be based on a right conceptual basis. The regulators should properly put accents of making out macroeconomic policy referring to the air transportation market. Possible alternative versions of macroeconomic regulation are given in the Scheme 1.



Scheme 1. *Possible versions of macroeconomic regulation*

We suppose that the choice should be made to the side, firstly, the theory of offer, as a basic regulation concept. Secondly, macroeconomic regulation direction, taking into account active transforming processes in world economy (to some degree transition aspect) should be priority. In the choice of stabilization versions, it is necessary in case of activation of the transforming processes the accent should be made on structure-production stabilization leaned against qualitative effective financial instruments. The choice of financial instrument types must be rather weighed, but it is clear that in any case (both in the case of orthodox and heterodox approaches) the accent must be put on stabilization of money circulation and rate of exchange of national currency unit.

It seems that in case of correct orientation of macroeconomic regulation both air transportation market and the country as a whole will get the impulse for development and, that is rather important, will keep its stability in development.

Nowadays most important forms of state regulation of air transportation market are as follows [1; 5]:

1. Direct state participation in airlines activity, in the first place in connection with state interests to keep and promote strengthening national carrier positions.
2. Guaranteeing support of regional companies by local authorities.
3. State support of airport network as an important element of national infrastructure.
4. State participation in financing projects of airport complexes' reconstruction.
5. Optimisation of taxation processes, subsidizing and establishing the prices on the market.
6. Participation in personnel training and retraining process.
7. State risk-management in air transportation sphere.

4. Macroeconomic Risks and Risk-management of Airlines

ICAO as one of the main ways of air transportation development and their regulation calls the necessity of working out recommendations in the sphere of risk government system [6].

Therefore state regulators must pay special attention to this aspect. In this connection it is necessary in the first place to provide correspondence of state policy in the sphere of air transportation market regulation with international rules and standards. In this case international principle must be the principle of priority. This is the condition of providing necessary safety level.

At the same time it is necessary that on the airlines level in the process of government macroeconomic component of business profitability be taken into account. Within the limits of investigations of the Company Sabre Airline Solutions besides other problems analysis of the factors preventing from raising profitability of airline business under modern conditions of their development is realized (Figure 2).

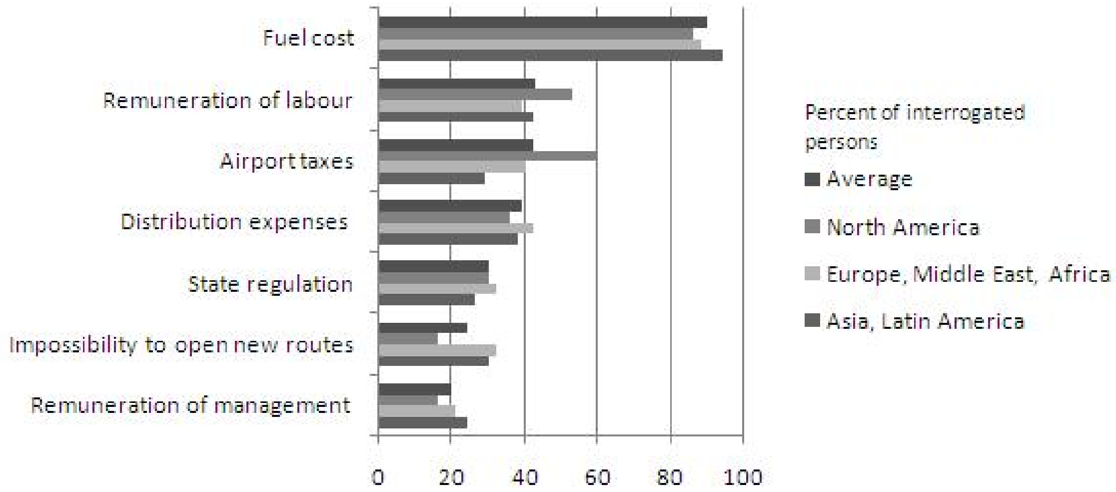


Figure 2. *Factors preventing from raising profitability of airline business*

Source: Sabre Airline Solutions [4].

The analysis has shown that the priority factors are as follows: fuel cost, remuneration of labour, airport taxes, distribution expenses and expenses connected with specific character of state regulation of airline market. The levels of above mentioned indices have essential distinctions in the countries of world community.

Therefore in risk-management airlines must take into consideration the presence of inter-country differences and their influence on profitability level. Aviation businessmen cannot influence these components especially in other countries; therefore, aviation business must reflect the presence of macroeconomic risks in corresponding financial calculations and risk-management. First of all, it refers to inflation risk, currency risk, risk of monetary policy changes in the country, risk of state regulation changes, and risk of country's social state.

Macroeconomic regulators must develop corresponding recommendations on accounting macroeconomic risks in airlines activity that will reflect the demands of international organizations including air transportation sphere.

5. "Human Factor" Risks of Airlines and Possibilities of Macroeconomic Regulation

Within the limits of air transportation market macroeconomic regulation "human factor" risks the level of which directly influences on the flight safety and profitability of airlines demand a special consideration.

In aviation business claims to "human factor" quality constantly grow. Firstly, claims to the quality of air pilotage for carrying out actively growing volumes of work both inside the country and abroad increase. Secondly, claims to the quality of service in conformity with the heightened service demands in the sphere of air transportation grow {7}. Thirdly, the quantity of extreme situations taking place in connection with air transportation realization increases.

Business-practice witnesses the fact, that the airlines are forced to spend great funds on training and retraining the specialists. Moreover there exists the cooperation of a number of airlines, in the first line, within the limits of air carries unions in the direction of joint financing and provision of training centres, working out curriculum with the purpose of modern and qualified training the necessary number of skilled personnel. Simultaneously the unification of the level of personnel training by airlines-participants of unions is reached [8]. Thus air-business concentrates efforts, financial are among them, in the sphere of training and retraining of the personnel that, first of all are directed on raising the flights safety level and saving expenses realization possibilities as well under the condition of capital centralization.

At the same time, general conditions of raising profitability of airlines become more complex, which is connected, as it was mentioned above, with the growth of air business costs components. Under these conditions airlines use “policy of economy” both in the sphere of capital assets’ utilization (infrastructure, aircraft, etc.) and in the sphere of cooperation with the personnel. The main problem in this aspect by aviation specialists’ opinion is the problem of service wear and consequently aircraft insecurity [5]. Side by side with this under the conditions of aviation specialist shortage and labour intensity is the reason for the adversely affecting the flight safety.

Thus under the overall growth of expenses in air business on training, retraining, stimulation and motivation of the personnel, the growth rate of their expenses does not compensate the growth rate of a man’s expenses on realization of labour functions in air transportation sphere.

We should add to this that the average age of aircraft specialists in civil aviation grows [5]. Aircraft specialists are actually strictly specialized specialists that make difficulties in their transition into other branch of economy. Some privileges in civil aviation partly stimulate the people to remain in aviation and continue working under the exiting conditions. But it is clear that the problems of civil aviation personnel motivation increase that demand solution.

Specialists in motivation’s sphere point out that necessity in safety and protection refers to man’s primary demands. On the basis of its realization, interest in labour, necessity in acquiring social status and requirement in self-realization are formed [9].

Under modern conditional civil aviation personnel, whose activity is originally connected with rather a high level of risk, do not have necessary guarantees for their own safety, such as guarantee of life saving, guarantee of health saving, guarantee of providing adequate payment to their families in case of bread-winner loss. In this connection “human factor” risks increase, which nowadays air business insure in a minimal degree.

It seems that state participation should be more active in this sphere. Within the limits of the article the necessity of widening the state participation in the process of training, retraining and changing specialty of aviation specialists is marked. The last point is mostly important as aviation specialists in case of, for example, loss of health, very often becomes “unfit”, “unnecessary” for aviation and consequently, they are lost for the society because of formerly acquired “narrow” specialty. Very often these are disciplined, responsible workers, and in case of changing specialty they can be claimed both in civil aviation and other branches. In this connection we’ll add the necessity of private airlines state stimulation, and their investments of funds in the process of personnel training. State support, in this case, promotes raising the training quality of aviation specialists and serves as the basis of flight safety increase.

As for the analysis of the state regulation problems of air transportation market it should be stressed upon that the problem of air accidents inquires quality and improvement of specially organized for these purposes independent state structures and demands a special investigation [5, 10].

At the same time the key problem under modern conditions is the participation of state and private investors in forming airline personnel social package including adequate to the character of activity of life and health insurance, granting vouchers to health centres, giving state subsidy for life conditions improvement (dwelling, transport facilities, etc.), granting privileges at getting education to civil aviation personnel family members, etc. In this case it is possible to speak about the formation of real interest in labour of airline personnel and raising flight safety level.

In case of aviation specialist’s death his family must receive adequate money compensation or payments but within a short time. In modern air business practice from the moment of air accident to the moment of receiving money compensation passes a long period of time. In a number of cases receiving money compensation is problematic, and its size is incomparable with the size of aviation specialist’s family losses.

If these problems are not solved, then in the course of time civil aviation may come across the “human factor” problems that become a real problem on the way of flight safety growth and profitability of airlines. Thus both the state and air business should be interested in solving the personnel’s problems.

6. Conclusions

Undoubtedly civil aviation belongs to the branches of great importance in the life of society. That's why the influence of the state on the development of this socially significant sphere of action must be especially weighed, rational and efficient. In the process of countries and air transportation market the development forms and instruments of macroeconomic regulation must be perfected, but in any case macroeconomic regulation must promote stability and reliability growth both in air transportation sphere and the country as a whole.

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PATIENTS' MOBILITY AND ACCESS TO INFORMATION OF MEDICAL SERVICES

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This paper deals with information systems support of the process, which is to provide medical services to patients without reference of their residence and the location of medical service centre. In conditions of increasing mobility it is necessary to find the ways of quality and efficiency improvement while providing medical services. Special attention is paid to questions, which show the index of information and services access in Latvian medical cluster. Choice of criteria and indices of telemedical project financial-economic evaluation, are being considered.

Keywords: *mobility, service, accessibility, telemedical systems, unified information zone*

1. Introduction

United Europe made it possible to change reasons of mobility and to increase some kinds of it, and what is more to form the so-called unified service market in different directions (finance, transport, telecommunication, commerce, insurance, pharmacology and medicine). Increasing people's mobility leads to vital changes in services market and makes new high demands on standards quality and speed of their provision. European market fragmentation is the objective reason which prevents from exchange of innovations and advanced experience. Taking into consideration the fact, that society is getting more and more information, service rendering operativeness increase takes place due to information- computer technologies implementation. Such categories as e-government, e-commerce, e-education are added with e-health as well.

In this connection formation and support of medical services unified market should assist the increase in all Europe's competition, as well as give movement freedom and medical services access to European citizens. On the one hand, waiting for a complete implementation of a universal European health insurance card (EHIC) should improve the situation in service access and give a wide range of possibilities to those, who are looking for medical service in other countries [1]. And on the other hand, it involves formation of a unified electronic data base platform with a wide range of opportunities to patient's European data base formation. Uneven structure of a unified medical market development in European Union countries stands in the way of services process individualization, which leads to their depersonalisation and quality decrease.

One of the main EU priorities is European citizen's health care, and public health is the primary service, provided to EU patients. It is necessary to realize the extent of responsibility for providing patient's equal access to necessary information about medical services in conditions of increasing mobility. Tendencies of growing mobility influence public health systems, but freedom of movement, given to European citizens by European agreements will only become real if patients get equivalent medical help being abroad. This fact (remark) would make the procedure of access for patients from near-to-the-border, thinly populated, insular geographic areas to highly technological medical centres and services easier. The project "Europe for patients", which is financed by FP6 EU of scientific researches, sets as its goal to find ways of solution for the mentioned problems [1].

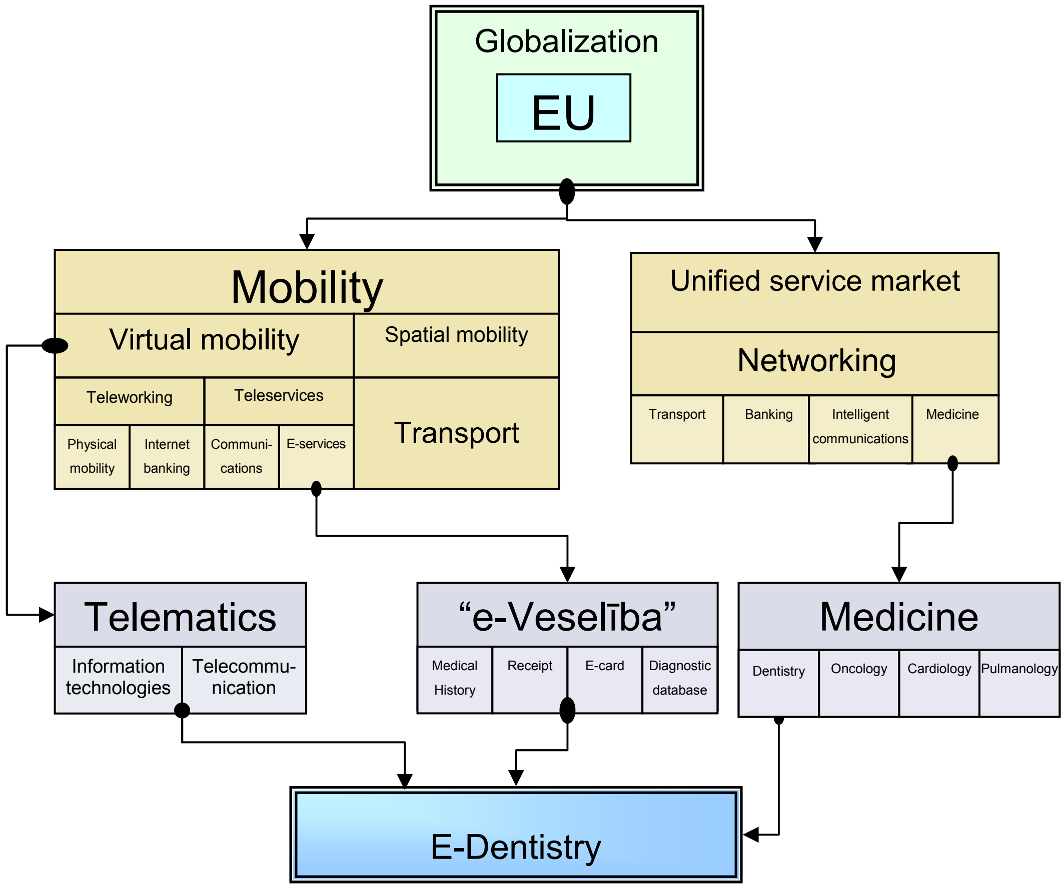

Figure 1. *Place of research in a unified information zone*

2. General Approach to Telematics

Each state faces the task to create some kind of a unified information zone, which could provide access to information about medical services rendering regular distant consultative-diagnostic help to various institutions and specialists, taking into consideration the fact that e-medicine is already an existing, independent, and extremely necessary sector of medicine. Specialists from different countries, who deal with public health awareness, realize the role of a unified information zone, but on the other hand they note the absence of officially accepted common principles of a unified public health information system forming and functioning. A single conception of a common health care information zone forming is needed and international standards for providing data base compatibility should be used. Main principles of a unified information zone forming and development could be the following:

- Functional standardization (on the basis of open information system ISO-ISO/TC215 "Health Informatics") [5];
- Identity compatibility;
- IT solution adequacy;
- Unification and coordination;
- Implementation of informative – computer technologies into public health.

According to the opinion of All-European Association of Medical Telematics – EHTEL – by modernizing European public health systems, by implementing informative/computer technologies we can lot upon rationalization potential in this sphere up to 20% – without losses in quality and quantity of the provided services. For all this it is necessary to take into consideration that implementation should be carried out in an open way, in coordination, having international standards as a basis. Presumably, from 20 up to 40% of all the public health services are based on informative/computer technologies, which include getting, storing, analysis and transfer of patients` medical data. Informative/computer technologies in public health, concerning banking and industry are used in a limited and not effective way.

Medical telematics, which provides direct e-health system functioning, is presented by various data exchange services, distant diagnostics and tele-consulting.

That is why before putting forward such a service to the market (to a consumer, user) there arises a question about the necessity of telemedical systems and networks formation in order to provide the support to e-health ES areas, which have already been created and should be classified according to the types given below:

- public isolated systems;
- private isolated systems;
- corporative systems;
- national integrated systems (for example national, E-health system in Latvia is presented as a complex of autonomous systems);
- European and above-national systems.

Such kind of system and network should consolidate medical institutions of different types and sizes in order to satisfy specialists' necessities.

Type:

- accident and emergency;
- diagnostic centre;
- transplantation centre;
- special hospitals;
- insurance companies;
- medical information centre;
- archives;
- telemedical institutions;
- statistics institutions.

Size:

- data exchange services;
- tele-consulting;
- distant diagnostics;
- health state monitoring.

Scientific knowledge and technological innovations make it possible to widen continuously the range of opportunities for structuring help provision. Information technologies are becoming an integral component of service providing as an instrument that gives a possibility to store and find information about patients, as well as help in making clinical and organizational solutions with the help of "knowledge management". New knowledge is becoming accessible in the mode of nearly real time, and one can get them being present in any part of the world. Telemedicine is developing very rapidly, which allows specialists to consult their colleagues and carry out distant diagnostics.

But it is necessary to take into consideration the fact that public health awareness criterion level is not defined in all the countries, and the amount of PCs in medical institutions is not an adequate index. So, for evaluation of usage of the informative/computer technologies in European Union, two main indices are used:

- part of population, that use Internet to get medical information – for EU and America it is 80%;
- part of doctors, that use electronic medical story card – for EU it is 25% (in Denmark – 75%, in America – 17%).

There are no such indices for Latvia at present, there is only general information about access of population to Internet – it is about 50%.

Day by day diagnostic methods are becoming more perfect, increasing the possibility of earlier and more precise diagnostics, which makes new requirements and public health services have to correspond to them [2].

World and European experience of telemedicine projects' implementation demonstrates the result of using new highly effective scientific-practical direction with a great social and economic effect. This is a real opportunity to improve the quality of medical services and provide the population with wide access to information about medical services. It also gives a possibility by means of the least expenses to implement a range of measures in order to improve medical service the whole, namely:

- to change fundamentally the approach to gaining of diagnostic information about a patient;
- to improve quality of data collection and analysis, their subsequent shelving and storage;
- to improve index of accuracy while diagnosing;
- to reduce time losses on additional examination, diagnostics and further treatment planning;
- to cut down considerably expenses for diagnostics and treatment;
- to improve index of service accessibility (taking into consideration that it means patient's money and time losses);
- to improve index of provided help quality.

Aims of such projects implementation into the field are to provide fair access to services, their high quality from the point of view of technical efficiency and adequate reaction on patients' waiting, as well as affective usage of the available resources.

On August 18th, 2005, Cabinet of Ministers of Latvia accepted main e-health regulations "E-health in Latvia", which were worked out by Ministry of Health. On May 25th, 2006 "Architecture of information system in public health sphere" was approved by IT Council of Ministry of Health (see Figure 2).

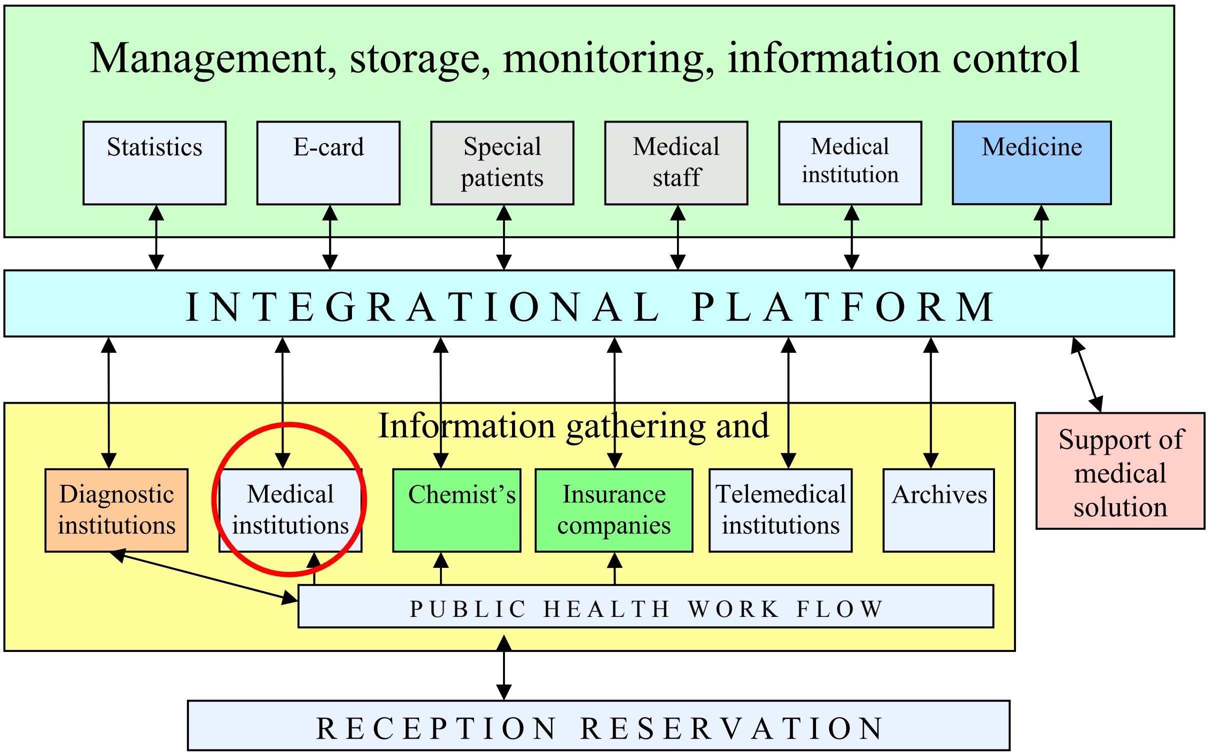

Figure 2. *Latvian National Integrated System of Future Medical Service Network*

The given document defines directions of information technologies strategic development for the near 10 years. The main tasks of "e-health" implementation are as follows [6]; [7]:

- to improve state of health by carrying out individual's control over their own health (providing a patient with the possibility of access to their own data base);
- to carry out effective decision making about health, increasing availability to information about sanitary events and publicising healthy lifestyle in the society;
- to increase public health effectiveness, providing quick access to medical services suppliers;
- to ensure availability of highly- qualified doctors` consultation in regions, having as a basis centralized visual- clinical diagnostic and telemedical solutions;
- to provide possibility to define, plan, realize and control public health policy on the basis of high-quality information about real situation in public health;
- to insure authenticity and reliability of public health data;
- to have a possibility to get objective statistical data.

According to the opinion of Latvian specialists in this sphere e-medicine will make it possible to regulate and improve effectiveness of public health system functioning in the country. But measures connected with improvement of effectiveness should be based on the understanding of the fact, how medical services are organized and provided in the country on the whole.

In Latvia, medical services of different types are provided by two sectors: state and private, which is necessary to take into account while carrying out the events connected with integration of e-medicine project, since absence of close links, interdisciplinary cooperation and information exchange could become a serious problem and misrepresent information about medical services which are provided and patient’s data.

Figure 3. *PPP – Public Private Partnership*

Successful systematisation and regulation of medical process are possible on condition of complete available information from all medical services suppliers, but electronic aspect of processes makes physician’s work more transparent, controlled, and effective. The above-mentioned measures create a basis for real project on telemedicine in public health of the country on the whole, turning telemedicine not into a rare experiment, but forming an independent, topical trend of medicine. Latvian telemedicine centre demonstrates some interesting experience: managers of this centre note special prospects of this system in the field of coordination and development of invasive, urgent, planned cardiology help. After implementation of this system in Latvia the centre showed its own intellectual potential and readiness to cooperate with other countries in public health sphere and it also demonstrated on a practical example advantages of telemedicine, which:

- in cases of emergency dramatically cut down the time for medical help provision;
- increase effectiveness of therapeutic measures owing to urgent electronic distant diagnostics (taking measurements – cardiograms and spirograms and this data transfer for further processing through the sound signal to telemedical centre with the help of portable device, CC7000d, using any channels of communications);
- electronic data (medical story) backlog and access to them on-line for specialists and patients through the key-word;
- getting a well-timed consultation without any physical visits to medical institution and without interrupting working process;
- evident cut-down of medical service expenses.

The given example can be a practical prototype for other branch specialists and institutions, rendering, planned, as well as urgent medical help and providing diagnostic-consulting service.

Having as a basis already existing regulations, which have been developed in the field “E-health in Latvia”, the present paper suggests to define place and typology for creating an independent module, such a cluster in public health as dentistry, as well as to evaluate the necessity of giving a ground for placing information, which is at a disposal of specialists of the indicated field – “Architecture of information system in public health sphere”, to define groups of users, who need such information, to mark the limits and access possibilities.

Analogous projects, but in a more limited range, have been developed in a real analysed dental institution “Dent”. Computer software, which has been used for a long time, makes it easer to keep, collect, search and backlog medical, financial, administrative papers, to keep statistical information, to manage personal data base, to carry out electronic paper circulation with various insurance companies in Latvia, to suggest personal optimal interface. It can be stated that computer software usage (“Dent – automation on the basis of Gain CRM”) in dental practice has become during the years an integral part of doctor’s practical activity. Using of high-technology kinds of dental help, technical-diagnostic means, modern branch programme products (“Implant-assistant”, ‘Dolphin imaging”), personal knowledge data made it possible for dental practice to create distant diagnostics and tele-consulting services, as well as to exchange data in groups:

- doctor – patient;
- doctor – doctor;
- clinic – clinic;
- clinic – diagnostic centre, irrespective of object location.

Nevertheless, an important element for development of different kinds of telemedical networks and systems (levels – see “Types of systems classification”) is economic evaluation of telemedical project efficiency in particular. It is obvious, that necessity of reducing expenses increasing of efficiency and services accessibility forced to analyse how medical system services are organized and provided. Implementation of telemedical systems into dentistry, in contrast to other medical trends, has a range of peculiarities because of the specific character of provision of the dental help.

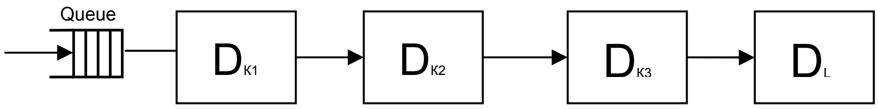

Figure 4. *The scheme of analysed process*
(D_K – Doctor’s consultation, D_L – Treatment)

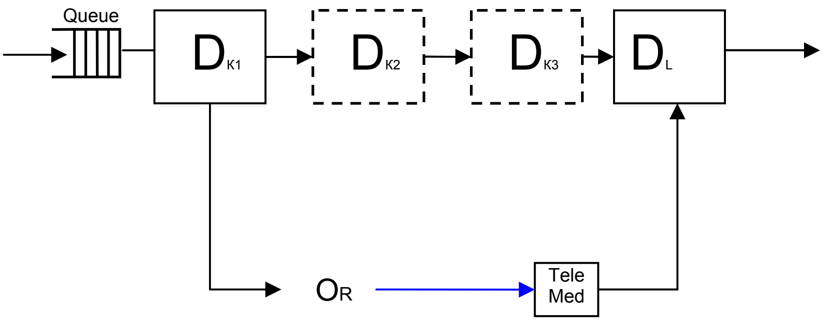

Figure 5. *The scheme of projected process*
(OR – Diagnostic data collection, TeleMed – Telemedical centre,
Data transfer channel)

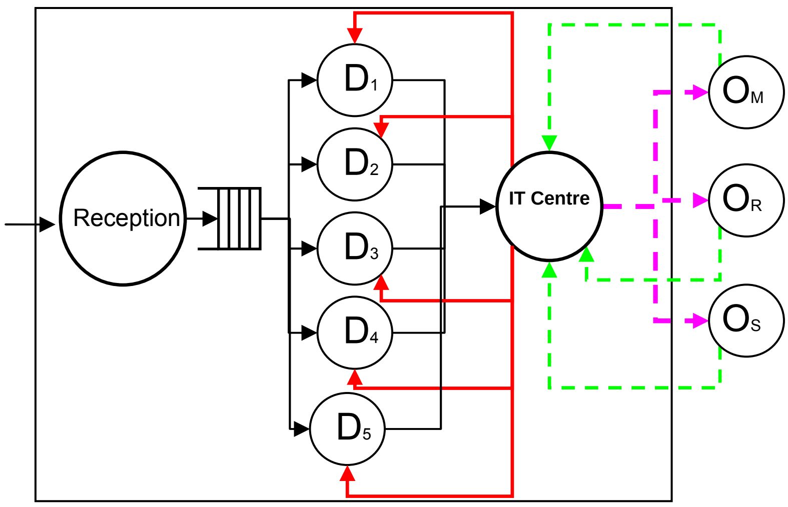

Figure 6. *Distant diagnostics and tele-consulting scheme*
(Conventional signs:
IT Centre – Telemedical Centre of an Institution
O_R – Diagnostic centre
O_S – Corresponding consulting centre
O_M – International telemedical centre (consultant)
D_1 –D_5 – Doctor)

Choice of criteria and indices of financial-economic evaluation of telemedical projects is not a simple task, as there are no formal research of cost and efficiency comparison, as well as methodologies of telemedical projects economic evaluation (due to some authors` opinion [3] and [4]).

One of the important service criteria is temporary characteristics, since, as a rule, financial and time expenses are included into the index of accessibility:

$$T_{MS} = T_{W.} + T_{oth.}$$

$$T_{W.} = T_{OUT.F} + T_{IN.F.}$$

Conventional signs:

T_{MS} – time of medical service
T_W – waiting time
$T_{OUT.F}$ – outer factor time
$T_{IN.F}$ – inner factor time

$$\Pi_{oper} = \frac{1}{T_W},$$

$$\Pi_{ass.} = \frac{1}{1 - \Pi_{oper}}.$$

While evaluating medical service availability, it is necessary to take into consideration time expenditure for search (through any communication channels), way to and time spent on waiting for doctor's consultation. Time losses, that precede service, exceed waste of patient's time spent on the direct contact with service performer and reach the ratio of 20:1 [4]. Evaluation of time spent on serving is seen in different ways: time losses for waiting to be served the consumer evaluates as negative, but for contact with the doctor – as positive. Losses of time while waiting for doctor's consultation can be taken into consideration in the criterion of service conditions, as well as in the criterion of service availability. This statement makes it necessary to improve the method of service provision and to search the ways of the improvement of its efficiency.

Time expenditures while calculating quality integral index can be transferred into means or the main indices of clinic work can be grouped into a model of final results, where indices of good results and defects are taken into consideration.

Index of a successful medical activity, (dental) practice – is totality of medical, economic and patients' satisfaction indices:

- number of refusals;
- the amount of the provided services;
- temporary disability duration after surgical manipulations;
- the amount of carried out well-grounded extirpations;
- appointment delay time.

Indices of good results correspond to ideal standards, taken for Figure 1, but it is a negative result if there is index of defects.

Index of defects:

- neglected cases proportion;
- incorrectly made diagnosis;
- incomplete service provision.

All indices standards cannot be achieved simultaneously in practice; accordingly, the real final estimation will always be less than Figure 1, which reduces the final index. The received integral estimation reflects medical practice effectiveness.

Such a sector of medical telematics as telematics in the field of medical services management, covering informative-communicational technologies in planning, realization, financing and quality evaluation, organizational technical level and effectiveness of service rendering and its usage, widens the limits of service availability index.

3. Conclusions

The described implemented telecommunication infrastructure can be used as a real brunch prototype which provides links with other specialists and medical-diagnostic institutions. A unified information dental system implementation into "Latvian National Integrated System of Future Medical Service Network" will insure integration and interaction with outer informative systems, insurance companies, and medical organizations and will provide access to distant knowledge and ontology. It will increase availability and diagnostics quality indices and reduce time, which is spent on waiting on reception to the doctor.

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MULTILATERATION ERROR INVESTIGATION AND CLASSIFICATION. ERROR ESTIMATION

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The MLAT errors have their origin at TDOA measurement errors, as primary input information. These errors can be distinguished by many different criteria. The basic criterion is mechanism of error origin, for example. Under this criterion the errors can be split into the main categories – temperature dependence and aging of the HW component. In this article the analysis of errors of target localization using multilateration system have been made.

Keywords: *multilateration, accuracy, errors*

1. Abbreviations

ANS	Air Navigation Services
ATM	Air Traffic Management
GPS	Global Positioning System
HW	Hardware
MLAT	Multilateration
MODE S	Mode S Radar
MSSR	Monopulse Secondary Surveillance Radar
RMS	Root Mean Square
SNR	Signal to Noise Ratio
SSR	Secondary Surveillance Radar
TDOA	Time Difference of Arrival
TOA	Time Of Arrival
WAM	Wide Area Multilateration

2. Introduction

Errors of multilateration systems can be split into the main categories. For example:

- Errors, which are out of any user and/or system control ("natural" errors)
  - Signal to noise ratio, actual state of troposphere, terrain profile
  - Errors of SSR transponders of tracked targets
- Errors produced by the system (HW and SW implementation)
  - Quantization error
  - Antennas position error
  - Temperature dependence and aging of the HW components

3. Errors in MLAT Systems, Overall Description

From the TDOA measurements and MLAT data processing point of view it is more appropriate to categorize the corresponding errors by its statistical nature. Statistical model of MLAT error can distinguish 3 basic error categories:

1. Systematic errors σ_1.
2. Correlated errors σ_2.
3. Random errors σ_3.

Important mechanism is the speed of time variations of the corresponding error components.

3.1. Systematic Errors

Systematic errors are slowly varying in time and they are present in every TDOA measurement. Typically, these errors have the origin at additional delays' variations, regional and local troposphere changes and imperfect antennas position measurement, which are projected by various mechanisms to every TDOA measurement.

The additional delay is determined mainly by temperature dependence and/or aging of the HW components.

Projection of the errors corresponding to the antennas position measurement to the TDOA measurements strongly depends on actual positions of the tracked targets.

In the frame of the MLAT error statistical model this kind of errors (slowly time varying) can be significantly reduced by continuous calibration process.

3.2. Correlated Errors

This type of errors is slowly varying in time too, but it is connected only with TDOA measurements for individual targets located in the given domain of MLAT coverage region. These errors have typically origin at actual troposphere condition along the line of sight Target-Antenna. In the frame of the MLAT error statistical model it is only possible to monitor these errors and consequently exclude them from further MLAT data processing for targets located at "problematic" regions. For each MLAT receiving antenna and given MLAT geometry configuration it is possible to define map of "problematic" regions and subsequently exclude TDOA measurements corresponding to the targets in these regions.

Another type of correlated errors is caused by the multi-path signal propagation.

3.3. Random Errors

This type of errors has white noise character and is produced by additive external and/or internal noise at received signals (described quantitatively by SNR) and by quantization effects due to the digitalisation of the TDOA measurements.

The random error of the TDOA measurement has three main components:

Jitter of the leading edge of the pulse, caused by noise. Its standard deviation is in the optimal case:

$$\sigma_{SNR} = tr / \sqrt{(2*SNR)},$$

where

tr – the length of the pulse leading edge;

SNR – signal to noise ratio.

For the SSR pulse with typically tr = 70ns and SNR = 18dB:

$$\sigma_{SNR} = 70 / sqrt(2*10^{\wedge}1.8) = 6.2 \text{ ns}.$$

Quantization error of the Measuring Unit (MU), where MU is unit which is used to quantize time period in the Central Processing Station where all pulses from all receiving station are come.

$$\sigma_{MU} = \Delta t / \sqrt{12},$$

where

Δt is the discrete of the MU; Δt = 12.5 ns resp. 3.1 ns,

so the Quantization error is about σ_{MU} = 3.6 ns resp. 0.9 ns.

Random error dependent on used time synchronisation technology.

Common Time (CT) – Jitter of the leading edge of the pulse, caused by the air (optic) data link: considered to be $\sigma_r = 7 / \sqrt{12}$ [ns] = 2 ns (σ_r = 1ns for optic).

Distributed Time (DT) – random error caused by the "common view" time synchronisation (GNSS / reference transponder).

Estimated values σ_s = 1 to 6 ns.

The overall standard deviation of the TDOA measurement consequently is as follows:

$$\sigma_{TDOA} = \sqrt{(2 * \sigma2SNR + 2 * \sigma2MU + \sigma2r)}$$ using common time technology, or

$$\sigma_{TDOA} = \sqrt{(2 * \sigma2SNR + 2 * \sigma2MU + \sigma2s)}$$ using distributed time technology.

The components σ_{2SNR} and σ_{2MU} are calculated twice, because two root squares are needed in creating a hyperbola.

When using common time, the typical overall random error for 1 pulse of SSR reply (e.g. F1 in case of A/C replies) consequently is the following:

σ_{TDOA} = 10.4 ns resp. 9.1 ns for the MU discrete Δt = 12.5ns resp. 3.1ns.

For the distributed technology, the figures are practically the same.

Using more SSR pulses enables better performance.

In the frame of MLAT error statistical model and subsequent data processing these errors can be significantly eliminate by two step processing:

averaging process, where corresponding standard deviation linearly decreases with the square root of measurements number:

- Kalman filtering process (tracking filter);
- Mode S replies/squitters generally provide better accuracy values.

4. Errors by Type of ITS ORIGIN

Up to now TOA errors of MLAT systems are not sufficiently classified and analysed, classifying them by place of origin, several types of errors might be identified. Each of them can influence on MLAT system performance namely:

1. Signal propagation errors –
   a. Propagation errors,
   b. Potential errors,
   c. Instrumental errors;
2. TDOA or timing errors;
3. Signal corruption;
4. Algorithm errors;
5. Survey errors.

Let's consider errors listed above more precisely.

4.1. Errors of Signal Propagation

This sort of errors can be sub classified as external errors and circuit errors. External errors are caused, for instance, by instability of radio wave propagation. Circuit errors can be divided on errors caused by noise and instrumental errors, which can appear due to imperfection of multilateration system nodes. Inappropriate adjustment/calibration of equipment can cause instrumental errors as well.

Noise acts a specific role. It is well known because of under the given shape of signal and signal to noise ratio (SNR), the optimal signal processing will provide a minimum error due to noise influence. Such minimum error is called potential error and characterizes the maximum accuracy under other ideal conditions.

Let us assume a normal distribution of random errors. Then the root-mean-square error (RMS) – $\sigma(\alpha)$ is as follows:

$$\sigma(\alpha) = \sqrt{\sum_{k=1}^{n} \frac{(\Delta\alpha_k)^2}{n-1}} . \tag{1}$$

Here, $\Delta\alpha k = \alpha 0 - \alpha k$ is an error of k measurement and $\alpha 0$ – is a true value.

Since random errors arise from different origins, their dispersions are coming into summation. The overall error of one receiving site is as follows:

$$\sigma_{\Sigma(td)} = \sqrt{\sigma_{prop(td)}{}^2 + \sigma_{pot(td)}{}^2 + \sum_i \sigma_{i(td)}{}^2} , \tag{2}$$

where:

$\sigma_{prop(td)}{}^2$ – propagation error due to conditions of electromagnetic waves propagation;

$\sigma_{pot}(td)^2$ – potential error due to noise;

$\sigma_i(td)^2$ – instrumental error, due to imperfection of receiver;

td – time of signal arrival to the receiving station (TOA).

It is easy to found the error depending on range based on TOA error using the following calculation:

$$\sigma_{r(td)}{}^2 = c * \sigma^2_{(td)}. \tag{2.1}$$

4.1.1. Propagation Errors

Errors due to propagation effects are systematic: any random variation will manifest itself as variations in the TOA.

The systematic error is dependent on the lateral distance and the altitude of the target since both of these factors affect the shape of the actual propagation path. There are two characteristics of the signal propagation that produce conflicting effects: a larger mean speed (due to decreasing refractive index) and a longer propagation path (due to refraction).

At smaller lateral distances, the propagation path is approximately linear and hence the dominant effect is the underestimation of the propagation speed. This causes the calculated straight line separation length to be smaller than the actual straight line separation.

At larger lateral distances, the propagation path is not linear and the actual path taken by the signal is longer than the assumed path. This causes the calculated straight line separation to be larger than the actual straight line separation.

As it was mentioned above, propagation errors arise because of unstable conditions of electromagnetic wave propagation. The RMS error of range measurement due to speed deviation from the assumed value can be calculated by means of equation $\Delta r/r = \Delta c/c$, where r is a range and c is assumed speed of electromagnetic wave propagation in the medium.

Considering ΔR and Δc as systematic errors and exchanging them to the corresponding RMS value, we can get the following:

$$\sigma_{prop(r)} = r\sigma(c)/c. \tag{3}$$

According to [1]

$$\sigma(c)/c \approx 2,7 \cdot 10^{-4}. \tag{4}$$

From this

$$\sigma_{prop(r)} = 2,7 \cdot 10^{-4} \cdot r. \tag{5}$$

From (5) it is clear that propagation error is proportional to the target distance.

4.1.2. Potential errors

Potential errors are caused by noise influence in case of known signal shape, and optimal signal processing. It will define the maximum measurement accuracy. For real devices all the time there is a sum of signal and noise at the receiver input. Noise oscillations have random amplitude and phase allocation.

It is well known that the potential accuracy due to the optimal receiving depends on signal bandwidth and SNR only. The potential error can be calculated as:

$$\sigma_{pot(td)} = [\Delta f_e \sqrt{2E_s / N_o}]^{-1}, \tag{6}$$

where

E_s – energy of pulse signal with duration of τ_p till detector (in intermediate frequency);

N_o – spectral density of the noise (noise power in the spectral interval of 1 Hz);

Δf_e – signal effective bandwidth;

td – time of signal arrival at k – sensor/receiver.

So, for instance, if $2E_s / N_o = 10$ and $\Delta f_e = 25MHz$, $\sigma_{pot(td)} \leq 12,5ns$.

4.1.3. Instrumental Errors

Instrumental errors are not investigated deeply yet, but it is necessary to take them into account in the future.

4.2. TDOA or Timing Errors

The principle of multilateration system work is based on Time Difference of Arrival (TDOA) method (Figure 1). Where 1, 2, and 3 are location points of the receiving stations. Central Processing Station is located in the reference point O.

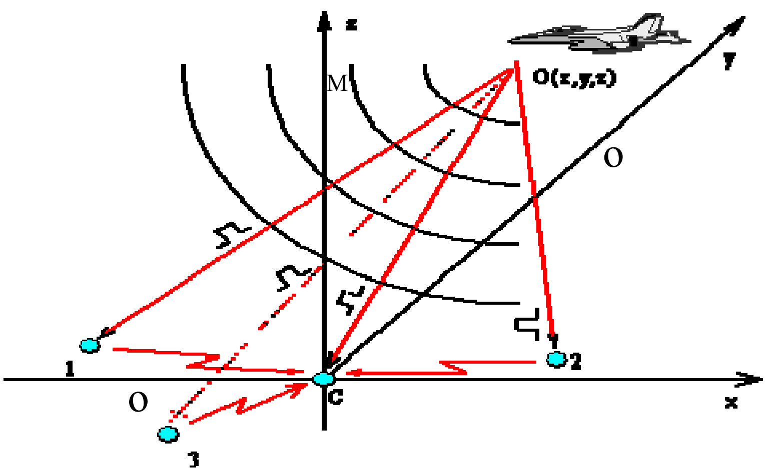

Figure 1. *TDOA principal of operation*

MLAT system calculates TDOA for each pairs of the receiver stations to locate an aircraft position. As an example for the receivers 1 and 2 range difference to the aircraft is:

$$\Delta r = c * (t_{d1} - t_{d2}), \tag{8}$$

where t_{d1} and t_{d2} are time of signal arrival for receiver 1 and 2 and c is a speed of light.

Let's assume that time of arrival errors are statistically independent for all sensors and therefore

$$\sigma_{1,2(\Delta r)}{}^2 = \sigma_{1(r)}{}^2 + \sigma_{2(r)}{}^2. \tag{9}$$

In practice location accuracy can be characterized with error ellipse (in plane) and with error ellipsoid (in space). For simplicity, let's take plane as it is shown on Fig. 2. Error ellipse is a locus of two components $l_x = \Delta x$ and $l_y = \Delta y$, which is equal to probability density of location errors in the plane.

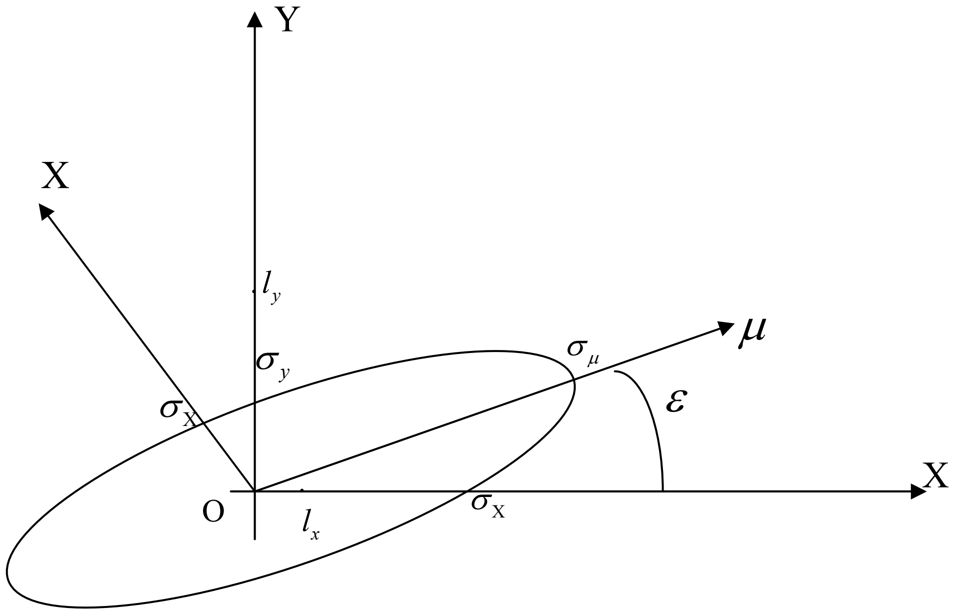

Figure 2. *Location accuracy*

Let's calculate position error for two receiving stations and one central processing station. For simplicity, let's assume the ideal situation when receiving stations (A and B) are situated on the reference axis and on the same distance from zero point (Figure 3) where the Central Processing Station is situated.

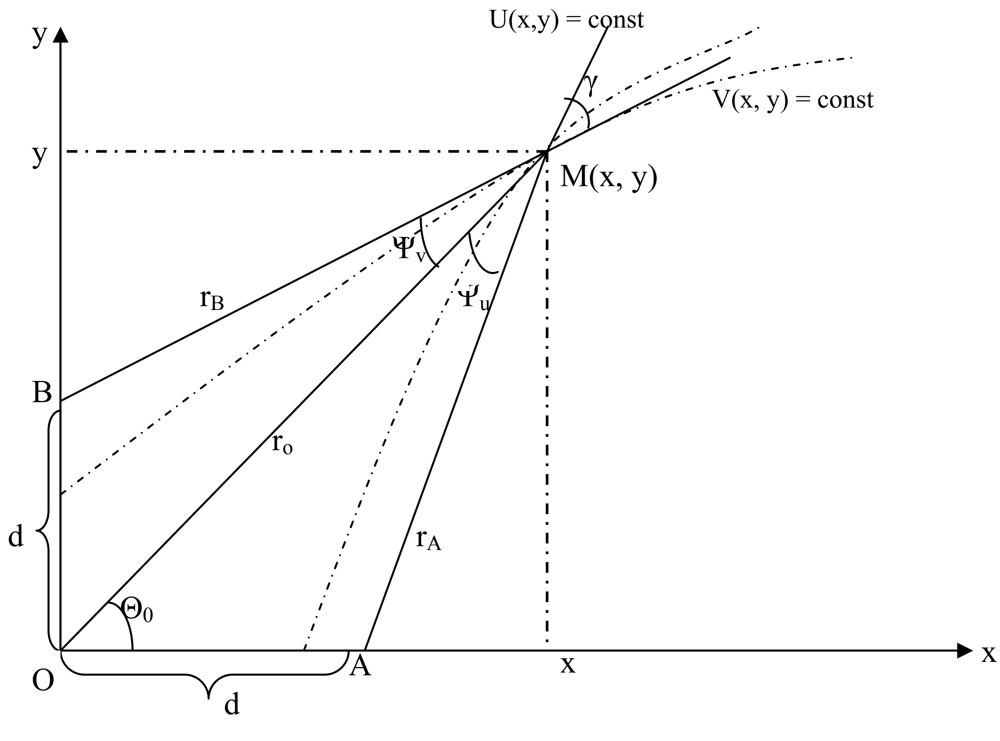

Figure 3. *Position of the aircraft*

The intersection of two positions lines u (x,y) and v (x,y) allows to calculate the position of an aircraft. Each position line (u (x,y) and v (x,y)) can be calculated by means of primary geometric parameter $n_u;n_v$ measurement.

RMS errors of position lines $\sigma_u;\sigma_v$ depend on primary measurements RMS errors.

To calculate position accuracy of the multilateration system it is necessary to calculate range differences nu = Δru = r0-rA; nv = Δrv = r0-rB from each receiving station to the aircraft M(x, y). The cross point of position lines (u,v = const) with the angle of γ gives position of the aircraft (see Figure 3).

The following calculations [2] help us to get range differences:

$$n_u(x,y) = u(x,y) = r_0 - r_A = \sqrt{x^2+y^2} - \sqrt{(x-d)^2+y^2}\,, \tag{10}$$

$$n_v(x,y) = v(x,y) = r_0 - r_B = \sqrt{x^2+y^2} - \sqrt{(y-d)^2+x^2}\,. \tag{11}$$

Assuming that $\sigma_n = \sigma_{\Delta r}$, the positional accuracy will be the following:

$$\frac{\sigma_r}{\sigma_{\Delta r}} = \left[1 - \frac{1-\frac{d}{r_0}(\cos\Theta_0 + \sin\Theta_0)}{q_s}\right]^{-1/2} \times \left\{\left[1-\frac{(1-\frac{d}{r_0}\cos\Theta_0)}{q_c}\right]^{-1} + \left[1-\frac{(1-\frac{d}{r_0}\sin\Theta_0)}{q_s}\right]^{-1}\right\}^{1/2}, \tag{12}$$

where

σ_r – RMS of the location finding;

ΔR – RMS of the range difference, which in this case is the same for both receivers;

and

$$q_c = \left[1 - 2\frac{d}{r_0}\cos\Theta_0 + (\frac{d}{r_0})^2\right]^{1/2}$$
$$q_s = \left[1 - 2\frac{d}{r_0}\sin\Theta_0 + (\frac{d}{r_0})^2\right]^{1/2}, \tag{13}$$

where r_0 and Θ_0 are polar aircraft coordinates from the same referent point.

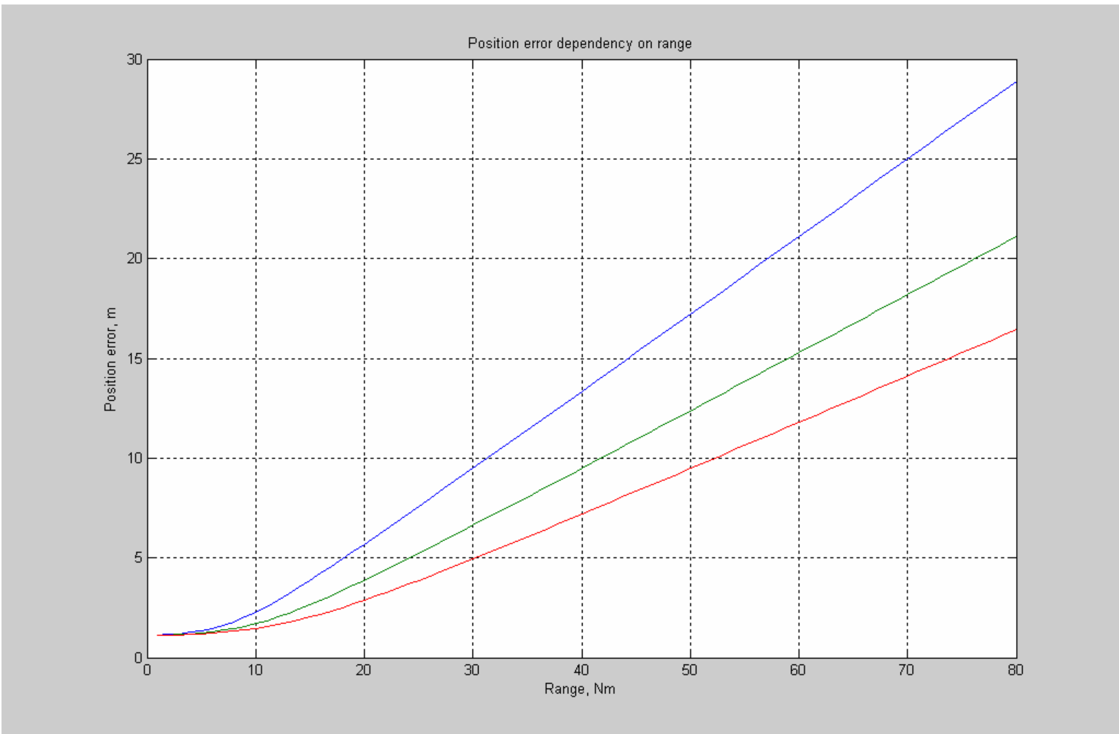

Figure 4. *Position – dependency on range*

Figure 4 shows the position error dependency on range for receiver station allocation like it is shown on Figure 3. Base between each receiving station and Central Processing Station – d is equal to 15, 20 and 25 km (red, green and blue curves correspondingly). As it was expected the position error is increasing with distance to aircraft and base between two receiving stations (from 15 to 25 km). As it is stated in this case the target is situated on the azimuth of 45 degrees. In case of calculation total errors of MLAT systems it will be necessary to take into account all other errors, which were considered in the first chapter of this article.

4.3. Signal Corruption

The transponder signal received by the system may be corrupted. This can be caused by a combination of multipath, garbling and potentially malicious or unintentional interference (jamming) conditions.

Multipath is where multiple copies of the same signal are received due to reflections from objects such as the ground, water, buildings or other aircraft. Antenna choice can help to reduce multipath.

Short path differences cause the same reply to arrive at multiple times with the pulses overlapping. Typically the direct and earliest path will be at a higher level than the reflected paths. These overlapping but attenuated pulses cause deformation of the pulse shape of the direct received signal. It usually has negative impact on TOA accuracy.

Long path differences result in multiple copies of the same reply to be received. If this is undetected it can cause ghost tracks, although due to the nature of the system, they do not last for long.

Garbling occurs, when two or more different signals are received that overlap in time. The probability of garble occurring on any given signal increases with the density of the SSR signal environment.

Both multipath and garble have an impact on the accuracy of multilateration system as well as affecting probability of detection. In many cases, especially with multipath, the signal itself can be recovered sufficiently for identification purposes. However the deformation of the signal affects the accuracy of TOA measurement or quality of the correlation. Accuracy can be maintained by rejecting these signals but at the expense of probability of detection.

If higher than expected levels of interference occur at a receiver this will also degrade accuracy. This is because the SNR of the received signal has a direct influence upon accuracy. If the SNR is particularly poor, the probability of detection and decoding ability may also be affected. In general multilateration receivers are relatively narrowband, being restricted to the 1090MHz signals, and thus interference is either directly in-band (typically malicious) or unintentional sidebands of other systems (e.g. DME).

Especially in large and complex airports, shadowing and multipath effects become important to the propagation of the SSR transponder signals. Multilateration systems use the SSR downlink frequency (1090MHz) and this is sufficiently high that the performance is limited to line-of-sight signal paths. Thus, there the blind spots or areas of unreliable coverage behind buildings may occur, etc. Reflections and multipath can cause degraded accuracy of position measurements or even ghost targets.

To limit the impact of these propagation effects, more than the minimum of 4 receiver sensors (the minimum required to derive 3-D position) will be required. It enables elimination of the false TOA caused by multipath and reflection.

Area Management mechanism for eliminating reflected signals from unreal locations (buildings etc.) is also applied.

Variable sensitivity of receiver dependent on the amplitude of received signals is also applied. The sensitivity is decreased to the level corresponding to the best signal.

Garbled replies are not being processed by the MLAT – the first or stronger reply is processed. If this creates a false reply, it is effectively eliminated in the Measuring Unit (based on TOA of F1 and F2 pulse or on the parity information). The probability of having the garbled replies received at all receivers at the same time is very low, which also helps eliminating the impact of garbling. Whisper-shout technique can be applied in case if there is a high garbling rate in the area.

Interleaved replies are far more probable than the garbled ones. Interleaved replies are detected by the Measuring Unit and are further processed.

4.4. Algorithm Errors

The main issue is to determine which type of algorithms for TDOA calculation will be used in the system. Typically this is being considered at survey stage and the influence of errors will be defined according to chosen algorithm: common clock system or distributed clock system.

- Common clock architecture benefits from a simple receiver with low power consumption and most of the complexity in the central multilateration processor. However the signal delay between the antenna and the multilateration processor puts stringent requirements on the type and range of the link. Typically a single hop custom microwave link is used, or dedicated fibre is laid between the sites as illustrated below. The location of the multilateration processor must typically be at the centre of the system to minimise communication link distances. So the errors which can arise in data link between receiving station and central processing station shall be taken into account.
- Distributed clock systems use a more complex receiver to reduce the demands on the data link. The RF signal is down-converted to a baseband or video signal and then the digitisation, code extraction and TOA measurement are all done at the receiver. This gives great flexibility in the data link as any digital data link can be used and the link latency is not critical. However a mechanism must be used to synchronise the clocks at the local sites.

4.5. Survey Errors

Survey errors will introduce uncertainties in the measured position of sensors and hence the construction of the hyperbolae. There may be some common systematic component of positional uncertainty which partially cancels out when establishing the aircraft position with respect to the sensors. A common systematic component will manifest itself when trying to refer the calculated position to a wider frame of reference.

Measuring the unknown position of a sensor will introduce both systematic and random errors. The random errors occur because a measurement is being made of an unknown quantity. Systematic errors occur due to unknown effects in the measurement system.

For a MLAT System, it is reasonable to assume that sensor positions will be determined using GPS or an equivalent satellite based system. The random errors for GPS measurements originate in the variation of the clocks in the satellites and the fluctuations in the propagation path due to the atmosphere.

Systematic errors originate in the variation of satellite orbits from the modelled orbit: real time position measurements must assume some knowledge of satellite position and there is often a deviation from this. Systematic errors also include any deliberate reduction in accuracy imposed by the GPS operators. Although Selective Availability (SA) has been switched off, the true accuracy of the GPS system is still reserved for the military and is not generally available.

Generally, sensor positions are surveyed infrequently and hence their impact on position measurement does not vary with time. Sensor surveying is mainly a one-off set-up measurement. The result of this, is that systematic errors may remain in the system for a long time, if not indefinitely.

Incorrect sensor positioning leads to an error in the calculated separation of a sensor pair and subsequently to the creation of the wrong hyperbola. The size of the positional error is more significant the further from the sensor axis. In addition to the creation of the wrong hyperbola, the surveying error may cause the hyperbola to be rotated with respect to the sensor pair.

Averaging the GPS position over a period of 24 hours is sufficient to reduce the random element of the uncertainty to below 1cm. Further improvements can be obtained by recalculating position after adjusting for the actual satellite positions. This data is generally available a day or two after the event but the calculations are non-trivial.

An absolute calibration is not strictly possible on the other hand it is possible to minimise or characterise systematic errors by surveying known locations

5. Error Estimation

Multilateration systems consist of several sensor elements distributed in space at which transmissions from aircraft can be detected. Detecting these transmissions and measuring the arrival times enables the difference in arrival time to be calculated for each pair of sensors. Combining the Time Difference of Arrival (TDOA) from several pairs of sensors allows the position of the aircraft, relative to the sensors, to be determined. Finally, knowledge of the sensor positions within a wider co-ordinate system allows the position of the aircraft to be determined absolutely.

At each point in this process there are opportunities for uncertainties and errors to enter the system and introduce an error in the calculated position. The purpose of this work is to identify types of errors at each point of the multilateration process and finally to derive a formula of error distribution of MLAT system in total.

In frames of work two types of TDOA measurement shall be taken into account. As it was said in the first part of the article, synchronization methods in MLAT systems can be classified as follows:

- Common clock systems. In these types of MLAT system the signal delay between the antenna and the multilateration processor puts stringent requirements on the type and range of the link.
- Distributed clock systems. The distributed clock systems use a more complex receiver to reduce the demands on the data link. The RF signal is down-converted to a base band or video signal and then the digitisation, code extraction and TOA measurement are all done at the receiver. It is possible to analyse and estimate error distribution by means of two ways:

1) Analytical way;
2) Statistical modelling.

Analytical estimation means to develop the mathematical derivation of error distribution formula. Analytical way of error estimation almost is not possible to do, because of difficulties in formulas which will be derived and differences of error sources and laws of its distribution (random or non-random).

Error distribution by means of statistical modelling will be analysed in the given work.

The method of statistical modelling will represent to be the model of signal plus noise passing through MLAT system's receiving tract. At the first stage it will be TOA errors or time of arrival errors. Forming the model it is necessary to take into account errors and its distribution laws in propagation medium (propagation errors) as well as errors, which can arise from the receiving point till Central Processing station.

Let's assume that at the input of receiver we have random process, which consists of mixture of useful signal and noise with zero average of distribution and correlation function. The main task of the model is to determine the average distribution and dispersion of the process at the output as well as law of error distribution for signal time of arrival at the output of receiver.

The same models shall be examined at each point of MLAT system. Forming the model it is necessary to use one of the mathematical packages, f.i. Mathcad and Matlab. To form the model of noise-like signal the measuring transducer with Weibull's law of distribution will be used.

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DEVELOPMENT OF LIEPAJA CITY MACROSCOPIC MODEL FOR DECISION-MAKING

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The most important things during transport infrastructure changing are the estimation and forecast of the traffic flow distribution over the transport network of the city. This article describes the example of using macroscopic simulation for decision-making during transport infrastructure changing. There exist plans in Liepaja city connected with the transport infrastructure changing. These changes include the new bridge construction over railroad, alternate streets creation, etc. The changes involve big investments, but the confirmation of effectiveness and practicability of such changes should be given. New transport infrastructure elements should cause big redistribution of the traffic flow on transport network of the city that's why for investigating the effectiveness and practicability modelling on macro level with the help of PTV VISION VISUM software application is used in the given paper.

Keywords: *macroscopic model, decision-making, VISUM model*

1. Introduction

Liepaja is one of the biggest cities in Latvia, with 85477 inhabitants registered in 2007 [1]. With the surrounding regions, there are more than one thousand inhabitants. The negative inhabitants' growth dynamics is observed [1]. At the same time the growth of private cars number is almost linear as could be seen in Figure 1. In 2006 the motorization level in the city was approximately 290 (private cars number per 1000 inhabitants) and it is growing at present. Accordingly, [1] the length of municipal streets has not been changed since 2000 that's why the transport infrastructure overloading is observed.

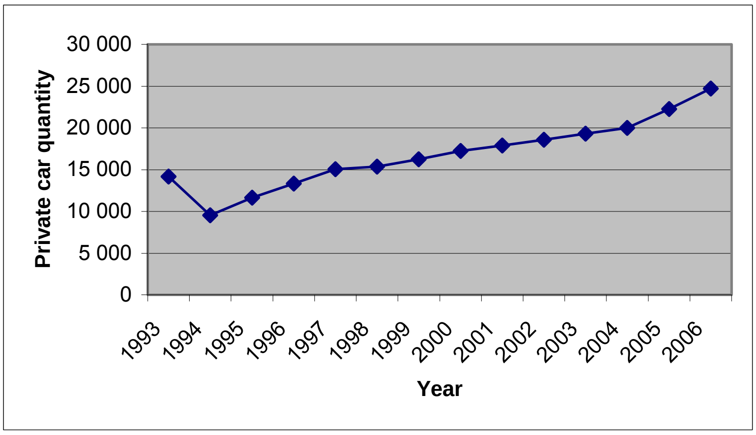

Figure 1. *Quantity of the private cars [1]*

Thus, in 2007 the city administration is planning wide changes in the transport infrastructure. These changes include as follows:

- Reconstruction of Karosta Bridge over Karosta channel (Karostas tilts).
- Alternate street creation for Brivibas Street from Riga side.
- New bridge construction over railway between Jaunliepaja and Ziemelu district of Liepaja city.
- Using Ganibu and Zirnu Streets as the streets with one way movement.

The task of analysing the effectiveness and practicability of these changes should be done. Also the decision about the number of lanes for the bridge over the railway should be made. Usually such tasks are being solved using modelling on macroscopic level. Description of macroscopic model construction and use could be found in [2, 3, 4]. But Liepaja macroscopic model does not exist, that's why the task of model construction and calibration appears. That is done using PTV VISION VISUM software [5].

2. Methodology of Model Development Using PTV VISION VISUM Software

For the model constructions there is used PTV VISION VISUM software which is one of the leaders in macro-modelling of transport flows. For the system of models development the special metamodel that is presented on Figure 2 is used.

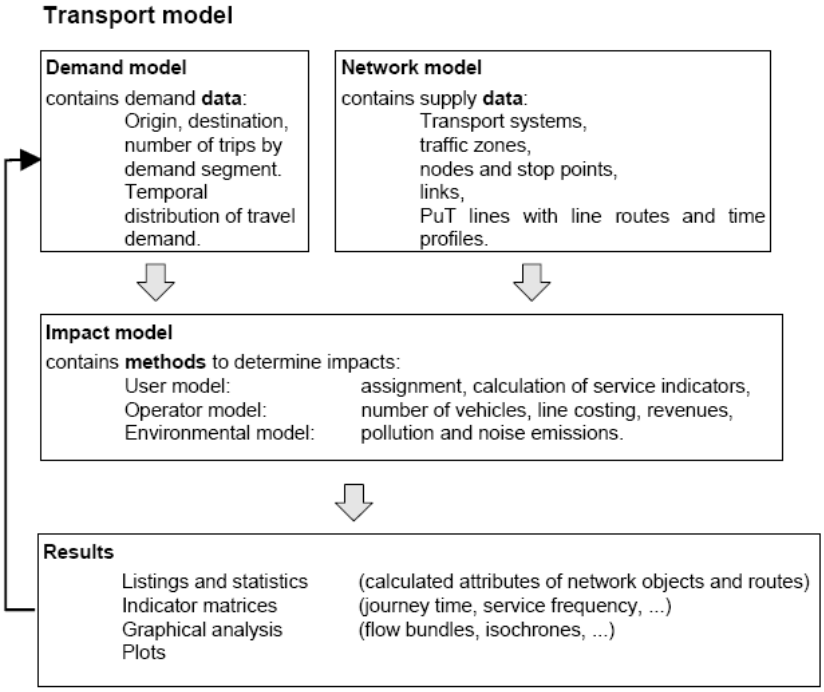

Figure 2. *VISUM transport model [6]*

The transport model normally consists of a demand model and a network model. The demand model contains the travel demand data. The network model describes the relevant supply data of the transport system. It consists of traffic zones, nodes, public transport stops, links and public transport lines with their timetable. The impact model takes its input data from the demand model and the network model. VISUM provides different impact models to analyse and evaluate the comprehensive transport system. VISUM displays the calculated results in graphic and tabular form and allows analysing the results graphically. In this way, for example, routes and connections per OD pair, flow bundles, isochrones and node flows can be displayed and analysed. The transport model like all models represents the abstraction of the real world. The model creation can be divided into few points which are described in details below.

Transport Infrastructure Development

This stage includes the development of the transport infrastructure using the system of special objects Nodes and Links, those objects representing roads intersections and roads accordingly. The nodes are connected with the links and in such a way the transport network is implemented. Of course before constructing network the scale should be defined, allowing the program to calculate the link length automatically. Also for all links a set of the following parameters should be defined:

- Speed restriction;
- Link capacity;
- Allowed transport systems.

Also for each node the allowed direction of moving should determined.

Zones

On this stage, the investigated object must be divided into zones. The zones of the model are represented as geometric shapes. But it should be taken into account that transport flow movement starts and ends in the zone geometric centre. It is not obligatory to define zone as the geometric shape; it could be presented as the point. Using system object called connector the zones centre must be connected with the transport network via nodes. In such a way incoming and outgoing points of flow can be determined. A lot of such connections for one zone can be defined. If a zone has more than one incoming/outgoing point, then the weight for each point should be defined. This weight defines the percentage of the transport flow which uses this node for getting into the zone and getting out of the zone.

Demand Model Development

The demand model defines the quantity of trips between different zones, with different goals using different transport systems. But in this work only one type of transport system – private transport system and no goals are defined and used. So the demand model is presented only with one OD matrix (origin destination matrix), which describes the volumes of traffic flow moving from one zone to another.

3. Model Construction and Calibration

Using methodology described above the model of transport infrastructure of Liepaja city is constructed (Figure 3).

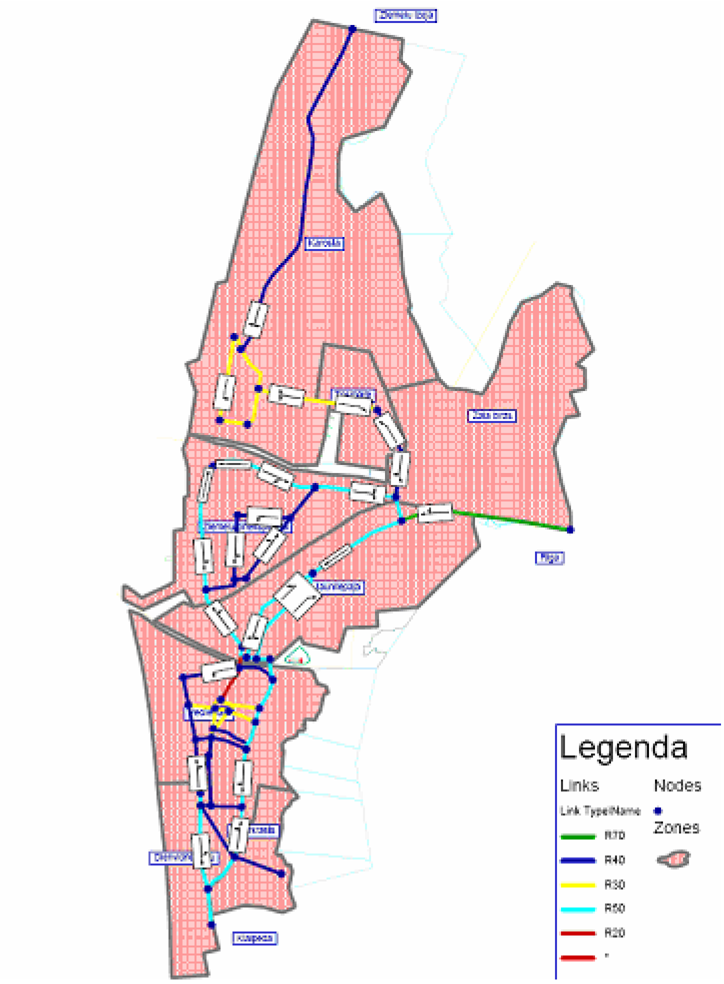

Figure 3. *Transport infrastructure of the city*

Constructed model presents the most important elements of the city transport infrastructure. 50 nodes are defined in the model. They present the main crossroads. Using different types of objects links the nodes are connected to the network. Types of the object link are presented in different colours in Figure 3 and described in detail in Table 1. For each link possible capacity is defined. The connection between speed and capacity for each type of the link is also described in the Table 1.

Table 1. Link type description and connection between speed and capacity for one lane

Type of link	Description	Capacity, cars
R70	Speed limit is 70 km/h	870
R50	Speed limit is 50 km/h	620
R40	Speed limit is 40 km/h	490
R30	Speed limit is 30 km/h	370
R20	Speed limit is 20 km/h	250

In the model of Liepaja 8 zones according to zones implementation theory [7] are defined. As the main factors of division there is used the information about number of inhabitants in each zone and the number of work places per zone. Also 3 external zones are defined. External zones are used for the model traffic flows which go to the city from the external directions. These directions are Klaipeda, Riga and Ziemupe. To connect zones with the transport network 26 objects of the type connector are used. Connectors define entrance and exit point from the zone. As the zones are relatively large, few connectors for one zone are defined. The share is determined by the weight which presents the percentage of the traffic which uses this connector for entering/leaving this zone (Figure 4).

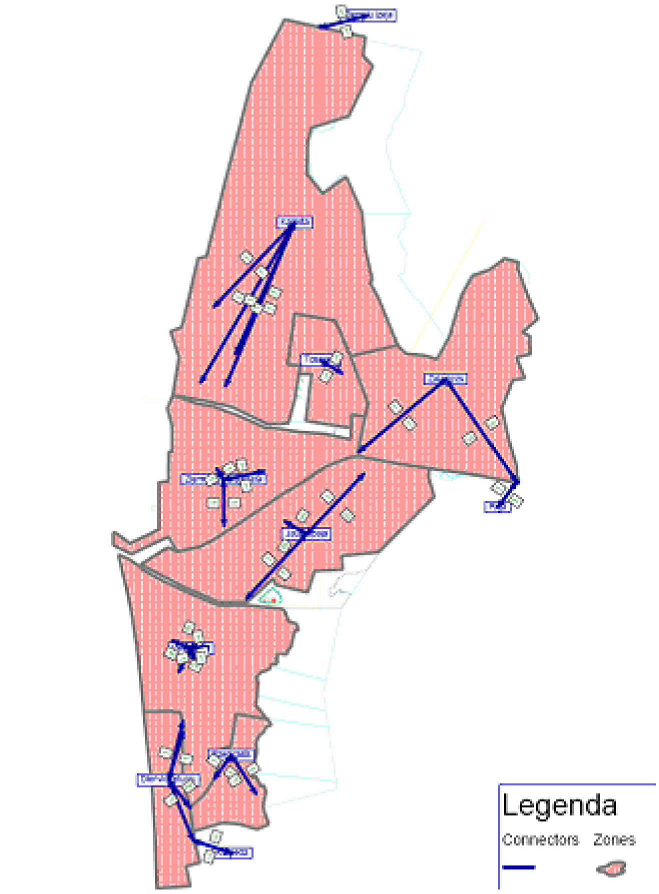

Figure 4. *Zones and Connectors with weights*

The share weight is defined according to the information about the number of inhabitants in the parts of the zones, which are located near the transport infrastructure.

The second stage of the model creation is the demand data definition. The demand data in the software should be presented as OD matrix (origin-destination matrix). Origin-Destination matrix defines the traffic volume between zones. The data reflect picture of traffic for morning peak hours (9:00–10:00) for 2007. OD matrix is presented in Figure 5.

Zones			1	2	3	4	5	6	7	8	9	10	11
	Name	6549.600	Dienvidrietu...	Ezerkrasts	Vecliepaja	Ziemelu prie...	**Jaunliepaja**	Zala birzs	Tosmare	Karosta	Riga	Klaipeda	Ziemelu izeja
	6549.600	Totals	645.800	224.400	2003.400	845.000	**1496.600**	341.800	481.800	170.800	261.000	65.000	14.000
1	Dienvidrietumu	378.500	5.100	14.400	150.000	35.000	100.000	21.000	21.000	10.000	16.000	5.000	1.000
2	Ezerkrasts	751.700	15.500	22.200	300.000	68.000	200.000	42.000	42.000	19.000	32.000	9.000	2.000
3	Vecliepaja	1064.000	125.000	45.000	200.000	115.000	320.000	71.000	71.000	33.000	65.000	15.000	4.000
4	Ziemelu priekspilseta	1085.000	22.000	40.000	203.000	354.000	263.000	57.000	57.000	28.000	45.000	13.000	3.000
5	Jaunliepaja	1042.800	376.800	29.400	296.400	69.000	126.000	42.600	42.600	21.000	33.000	5.000	1.000
6	Zala birzs	529.000	11.400	20.400	213.000	45.000	138.600	25.200	31.200	16.200	24.000	3.000	1.000
7	Tosmare	324.000	22.000	7.000	75.000	17.000	30.000	10.000	142.000	5.000	12.000	3.000	1.000
8	Karosta	464.600	54.000	15.000	177.000	41.000	70.000	26.000	28.000	18.600	28.000	6.000	1.000
9	Riga	752.000	12.000	26.000	330.000	75.000	212.000	40.000	40.000	17.000	0.000	0.000	0.000
10	Klaipeda	130.000	2.000	4.000	47.000	21.000	30.000	6.000	6.000	2.000	6.000	6.000	0.000
11	**Ziemelu izeja**	**28.000**	0.000	1.000	12.000	5.000	7.000	1.000	1.000	1.000	0.000	0.000	0.000

Figure 5. *OD matrix for Liepaja for 2007 (morning peak hours)*

The third stage of the model construction is the model calibration. The need to do calibration of the model is connected with a lot of parameters which should be defined. Some of the model parameters – such as link capacity, share of connections are determined exactly. But some are hand-picked. In this work 2 parameters are hand-picked. The first parameter is the assignment algorithm and the second one is the volume delay function (VDF).

Assignment Algorithm

In VISUM there are realized 6 private cars assignments algorithms [6]. They are the following:

- *Incremental*
- *Equilibrium*
- *Equilibrium_Lohse*
- *Multi_Incremental*
- *Multi_Equilibrium*
- *Multi Equilibrium_Lohse*
- *Stochastic*
- *Dyn Stochastic*

The incremental assignment algorithm is chosen. The main idea of the algorithm is to share OD demand per iteration. That's why the share should be defined. The result of share matching is presented in Figure 6.

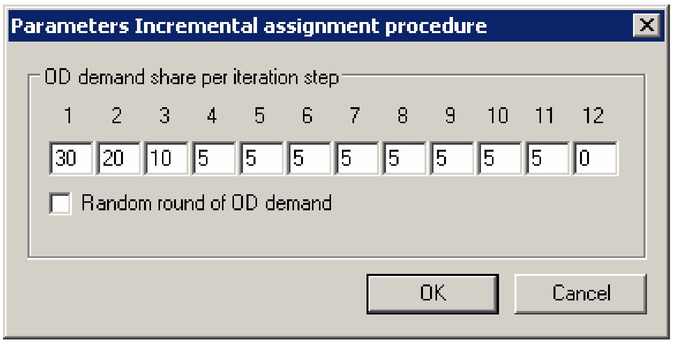

Figure 6. *OD demand share per iteration step in percent*

The purpose of the assignment algorithm is the distribution of the transport flow over the transport network. Process of choosing assignment algorithm and its parameters is done by the help of experts', because the real data of the transport infrastructure loading are not presented. The expert defines if the transport flow distribution over the transport network being realistic or not.

Volume Delay Function

Also the volume delay function (also known as capacity restraint function) is defined. For this model only one volume delay function is used for all the types of link. The volume delay function defines the travel time on a link in the loaded network. There are 14 of VDF presented in VISUM [6]. The volume delay function called BPR3 is chosen. The form of the chosen VDF is presented below [6]:

$$\begin{cases} t_{cur} = t_0 \cdot (1 + a \cdot sat^b) & \text{if } sat < sat_{crit} \\ t_{cur} = t_0 \cdot (1 + a \cdot sat^b) + (q - q_{\max}) \cdot d & \text{if } sat \geq sat_{crit} \end{cases}$$

$$sat = \frac{q}{q_{\max} \cdot c}$$

$$sat_{crit} = 1$$

where t_0 – free flow travel time [s],

q – traffic volume [car units/time interval],

$qMax$ – capacity [car units/time interval],

t_{cur} – travel time in loaded network [s].

Using expert opinion BPR3 the function parameters are matched. They are equal to as follows:

$a = 1;\ b = 2;\ c = 1;\ d = 5\,.$

The calibration gives the realistic model of the transport flow distribution over transport network. The Figure 7 shows flow volumes on each link.

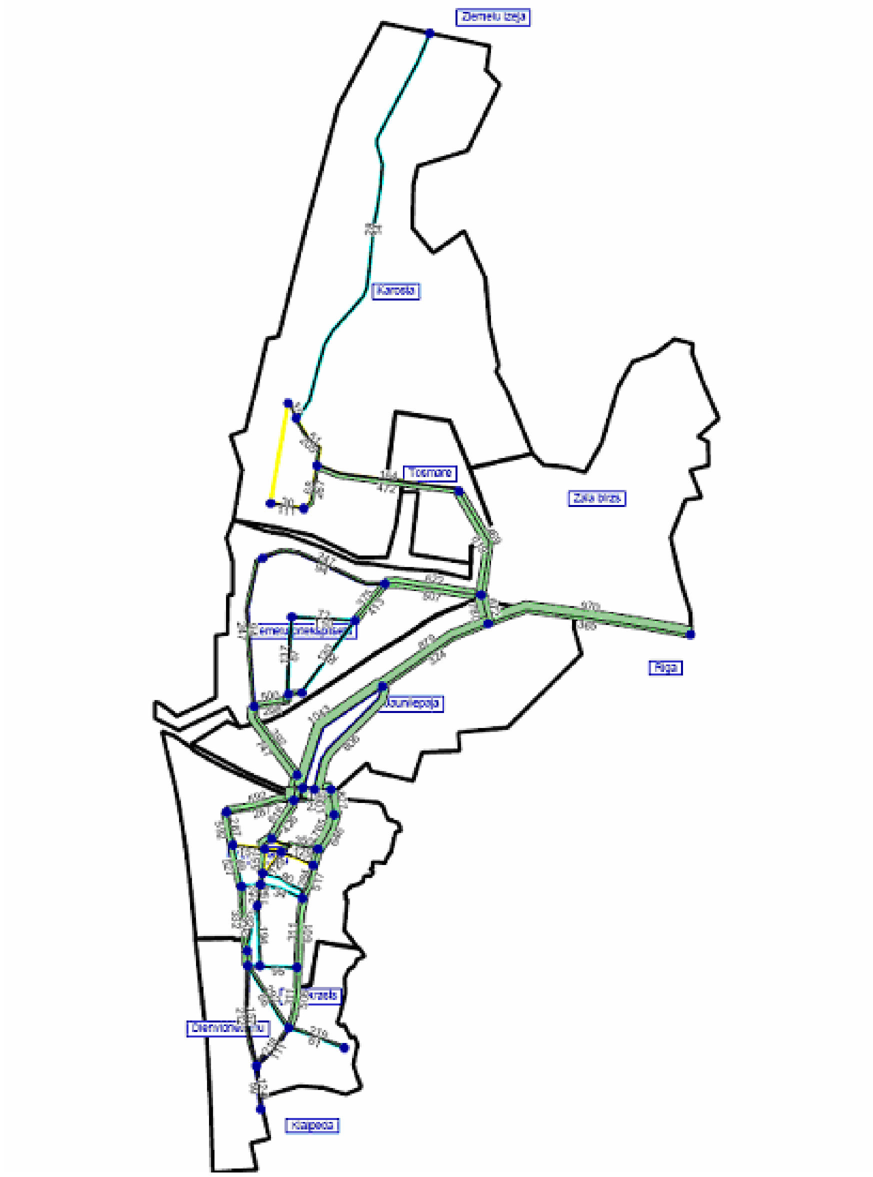

Figure. 7. *Transport flows distribution over transport network for 2007*

4. Decision-Making Using Macroscopic Model

The constructed macroscopic model is used for decision-making. Being based on the city plans 4 scenarios of transport infrastructure evaluation are developed. All the scenarios refer to 2018 that's why the OD matrix for 2018 is defined. For 2018 the matrix definition used the OD matrix for 2007, which was multiplied by the growth coefficient 1.7 according IMINK Ltd. The OD matrix for 2018 is presented in Figure 8.

Zones			1	2	3	4	5	6	7	8	9	10	11
	Name	11092.520	Dienvidrietu...	Ezerkrasts	Vecliepaja	Ziemelu prie...	Jaunliepaja	Zala birzs	Tosmare	Karosta	Riga	Klaipeda	Ziemelu izeja
	11092.520	Totals	1097.860	381.480	3665.780	1134.700	2544.220	581.060	819.060	290.360	443.700	110.500	23.800
1	Dienvidrietumu	643.450	8.670	24.480	255.000	59.500	170.000	35.700	35.700	17.000	27.200	8.500	1.700
2	Ezerkrasts	1277.890	26.350	37.740	510.000	115.600	340.000	71.400	71.400	32.300	54.400	15.300	3.400
3	Vecliepaja	2068.800	212.500	76.500	600.000	195.500	544.000	120.700	120.700	56.100	110.500	25.500	6.800
4	Ziemelu priekspils...	1542.700	37.400	68.000	345.100	300.000	447.100	96.900	96.900	47.600	76.500	22.100	5.100
5	Jaunliepaja	1772.760	640.560	49.980	503.880	117.300	214.200	72.420	72.420	35.700	56.100	8.500	1.700
6	Zala birzs	899.300	19.380	34.680	362.100	76.500	235.620	42.840	53.040	27.540	40.800	5.100	1.700
7	Tosmare	550.800	37.400	11.900	127.500	28.900	51.000	17.000	241.400	8.500	20.400	5.100	1.700
8	Karosta	789.820	91.800	25.500	300.900	69.700	119.000	44.200	47.600	31.620	47.600	10.200	1.700
9	Riga	1278.400	20.400	44.200	561.000	127.500	360.400	68.000	68.000	28.900	0.000	0.000	0.000
10	Klaipeda	221.000	3.400	6.800	79.900	35.700	51.000	10.200	10.200	3.400	10.200	10.200	0.000
11	**Ziemelu izeja**	**47.600**	0.000	1.700	20.400	8.500	11.900	1.700	1.700	1.700	0.000	0.000	0.000

Figure 8. *OD matrix for the year 2018*

The scenarios are defined as follows**:**

- The first scenario. Base scenario.

The first scenario, also called the base scenario includes only the elements of transport infrastructure, which will be realized till 2018. These elements are the following:

- Reconstruction of bridge Karosta (Karostas tilts).
- Alternate street creation for Brivibas Street from Riga side.

- The second scenario.

This scenario is developed according to the base scenario with some addition. This addition involves the new bridge construction over railroad. This bridge will connect Jaunliepaju and Ziemelu areas of Liepaja city.

- The third scenario.

The third scenario includes the transport infrastructure elements mentioned in the base scenario and uses Ganibu Street and Zirnu Street as the streets with one way movement.

- The fourth scenario.

This scenario includes the base scenario and the changes mentioned below:

- New bridge construction over railway between Jaunliepaja and Ziemelu district of Liepaja city.
- Using Ganibu Street and Zirnu Street as the streets with one way movement.

For each scenario the constructed model is updated according to the scenario description. The volume of traffic and the volume capacity ratio for each link are taken as the main research results. As the example the volume for the fourth scenario is presented in Figure 9.

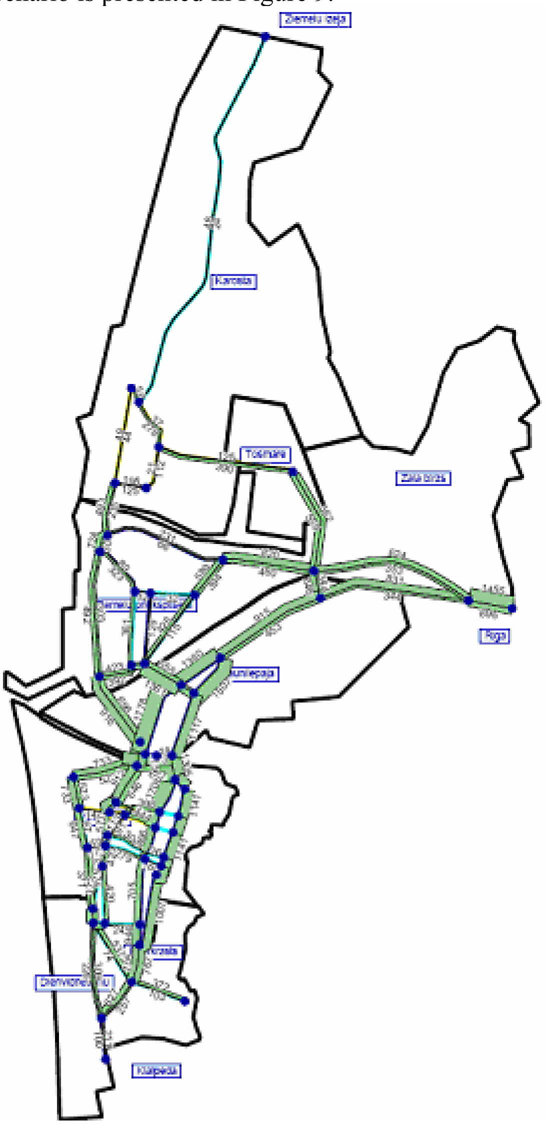

Figure 9. *Traffic volumes for the 4th scenario*

The flow volumes over new bridge prove that the construction of the bridge will be practical, because the traffic volume will be approximately 1400 cars on one side and approximately 850 cars to the other side. Firstly, the bridge in the model is implemented as the road with one lane per direction. But, accordingly, the model data volume capacity ratio will be very high, approximately 120%. This means that the road will be very popular but the junctions still will appear. So the lane number on the bridge is changed to two lanes per direction and volume capacity ratio becomes 80%. Such value proves that this road will be used and the bridge will not be overloaded.

For a moment according to the base model, Ganibu Street is overloaded considerably, approximately for 110%. The idea to use one way road with two lanes for increasing capacity of the road appears. This road will go to the southern part of the city. But the second road, which goes to the north, should be implemented. According to the plans Zirnu Street is chosen for the northern direction and will contain also two lanes. The result of modelling the third scenario shows that these transport infrastructure elements will be highly used and will not create junctions. Data from the model show that all the changes together are necessary and will lead to increasing the traffic load of some city infrastructure elements. But having analysed the situation in whole, we should conclude that the new projects of the transport infrastructure reconstruction must be implemented. As it is seen from the Figure 10 the city transport system is loaded considerably. The green link capacity volume ratio is equal to or smaller than 80%, yellow – is equal to or smaller than 120% and the red one – greater than 120%.

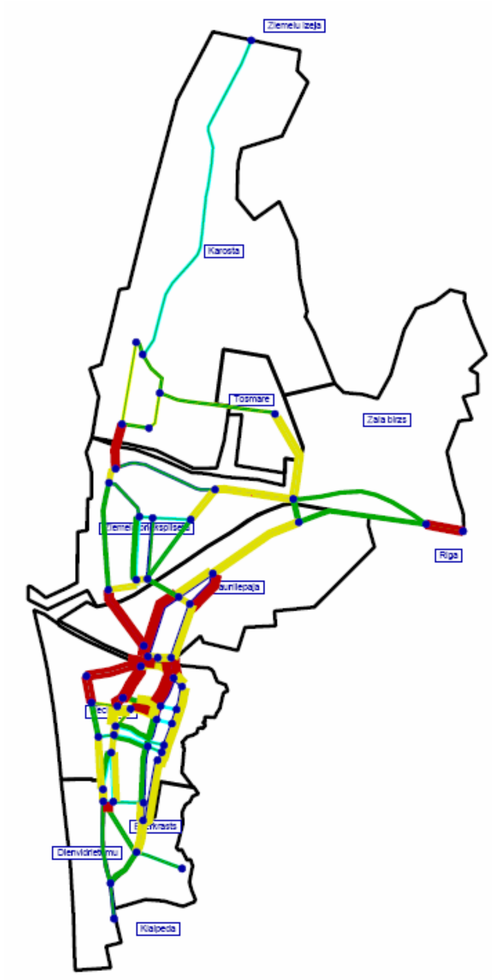

Figure 10. *Loading level of transport infrastructure*

5. Conclusions

The main goal of the work is to analyse effectiveness and practicability of the changes, which will occur in Liepaja transport infrastructure in 2018. For this purpose there is used modelling on macro level with the help of VISUM software. The model, which reflects the current state of transport infrastructure and transport flows is realized and calibrated by the help of experts'. The author underlines, that the opinion of the expert during calibration procedures should be taken into account to simplify the process of calibration if no real data being available. Using the designed model as the pattern, few scenarios are implemented and investigated. The difference between scenarios lies in the structure of transport infrastructure. Research results are mainly presented as the volume of traffic flow and volume capacity ratio for each link. Using these measurements the effectiveness and practicability of different scenarios are estimated and conclusions are drawn.

1. According to research data all scenarios will be effective. From practical approach all new transport elements will be used considerably. The volume of traffic on the new bridge over railroad will be approximately 1400 cars on one side and approximately 850 cars on the other side.
2. Also the decision about the lanes number for the new bridge over railroad is taken. The decision is taken basing on the volume capacity ratio. With one lane per direction the volume capacity ratio will be 120% and this is unacceptable, thus, the decision about two lanes per direction was made.
3. One-way roads on Ganibu Street and Zirnu Street are acceptable because of high level of using 1400 and 1300 cars per hour. And the volume capacity ratio decreases from 110% to 90%.
4. New projects of transport infrastructure changes must be implemented, because of the high level of loading central streets of the city.

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NEW PERSPECTIVES OF COACH TERMINAL AS IMPORTANT ELEMENT OF TRANSPORT INFRASTRUCTURE

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The main topic of this article is the further development of the coach terminal as a passenger infrastructure object towards the formation of a passenger logistics hub.

The coach terminal is an important passenger exchange point with the potential to be a connecting point with other means of transport – this should be taken into account when designing the further development of coach terminals in Riga. The operation of the coach terminal, the minimum services provided and the financing of the inland passenger transportation in the coach terminal are regulated by normative acts and will significantly affect the development of the coach terminal in future.

In the article the author stresses the essential factors involved in the operations of the coach terminal: planning of transport and infrastructure, information systems and other trends of development using the example of the JSC "Riga International Coach Terminal".

Keywords: *Coach Terminal, passenger logistics hub, information system, simulation modelling*

1. Bus and Coach Transport Importance in Public Transport

Bus and Coach Transport is the largest collective passenger mode in European Union-25: Over the last 10 years, the market share of bus and coach transport in Europe has stabilised at around 10%, with however a lower growth rate than in other transport modes. Nevertheless, bus and coach remains the most important mode of collective passenger transport in Europe, before rail.

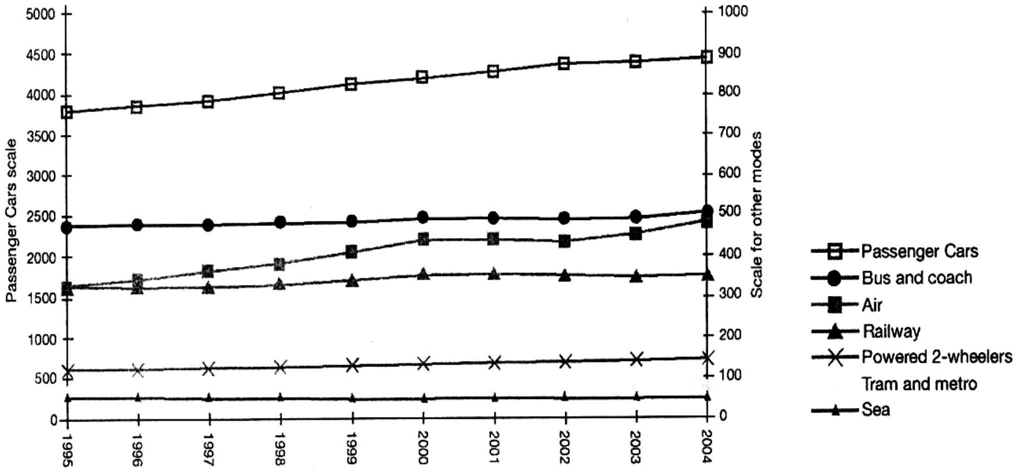

Figure 1. *Passenger traffic by different modes in Europe [1]*
Billion passenger kilometres

Recent studies on the role of buses and coaches seem to confirm the already excellent safety, environmental and social record of bus and coach transport. Apart from the private car, the main market competitor for bus and coach operators is low cost airlines. This situation can largely be explained by the existing distortions of competition in terms of VAT, mineral oil taxation and various types of public subsidies that other modes enjoy.

The typical bus and coach transport company in Europe (50% of all companies) is a micro-company, owing 2 to 10 vehicles (the structure is similar to that in the USA). There are as many larger companies of up to 50 vehicles (20%) as one-man companies (26%). 4% of the companies operate more than 50 vehicles. Profitability ratios differ significantly. As a rule, EU operators display a profitability rate of between 0–5% (1–2% in the USA), whilst the third country operators report substantially higher rates.

The place of the bus and coach transport in public transport in Latvia (million passengers per year) is shown on Figure 2.

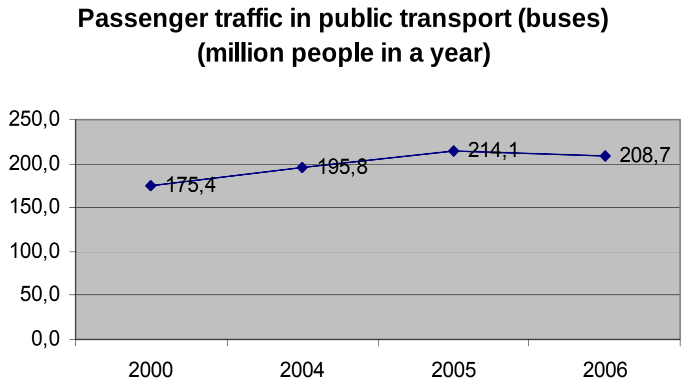

Figure 2. *Passenger traffic in Latvia*

2. Passenger Service and Providing of Intermodal Interchange in the Further Development of the Coach Terminal

Due to its geographic location Riga is not only the centre of Latvia, but of the whole Baltic area. Many important European transport corridors, state motorways, railway lines cross in Riga, the Riga international airport and the Riga port – navigable in all seasons – are located in Riga. These conditions are favourable for the development of all kinds of public transport, including passenger bus transport that is very flexible and can be deployed quickly in response.

The JSC "Riga International Coach Terminal" ("Rīgas starptautiskā autoosta") is located in the central part of Riga and it provides services to regional, long-distance and international routes, in average rendering services to 510 local and 60 international routes per day. Every year in average 5–6 million passengers receive the services of the terminal.

The Investigation "Development of Public Transport Route Destinations in Riga City" performed in 2006 by the "SIA Imink" forecasts the following growth of bus routes and number of passengers outside of Riga (see Table 1) [2].

Table 1. The forecast of the amount of bus routes outside of Riga and the amount of passengers served

N	Types of routes	2006				2008				2018			
		Amounts of routes	%	Amounts of passengers (ts.)	%	Amounts of routes	%	Amounts of passengers (ts.)	%	Amounts of routes	%	Amounts of passengers (ts.)	%
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
1.	International routes	60	5,2	1,9	6,6	65	5,3	20	6,7	70	4,1	2,2	5,2
2.	Long-distance routes	470	41,0	17,8	62,0	490	39,7	18,6	62,2	710	41,8	27,0	63,2
3.	Regional routes	616	53,8	9	31,4	680-700	55	9,3	31,1	920-940	54,1	13,5	31,6
Total		1146	100	28,7	100	1235-1255	100	29,9	100	1700-1720	100	42,7	100

In 2005 the company Solvers, Ltd. performed an investigation in order to determine the Riga International Coach Terminal as an interchange hub of passengers and linkage with the city public transport. The conclusions were essential for both the planning of the development of the Riga International Coach Terminal and the Riga public transport transit junction at Turgeņeva-Maskavas Streets [4].

While examining the passenger flow it is established that the services of the coach terminal are used by:

~4.0 thousand people in the morning rush-hours (9.00–10.00), including

- flow to the coach terminal ~1.4 thousand people
- flow from the coach terminal ~2.6 thousand people

~5.0 thousand people in the evening rush-hours (17.00–18.00), including

- flow to the coach terminal ~3.6 thousand people
- flow from the coach terminal ~1.4 thousand people

Most of coach terminal's visitors (~75%) moved in the direction between the coach terminal and the Central Railway Terminal Square, where most of the public transport stops are located.

Most coach terminal's visitors go to the coach terminal and leave it by public transport (70%–80%):

- by bus – 25%–30%
- by tram – 10%–25%
- by trolley bus –13%–20%
- by maxi-taxi – 7%–15%
- by train – 1 %–5%

An essential part of coach terminal's visitors come and leave as pedestrians (20%–30%). Obviously, basically they are people who come from the outskirts to Riga centre on business.

The coach terminal attracts transport vehicles: ~80–100 cars in the morning rush-hours and ~480–520 cars in the evening rush-hours. The coach terminal's attracted transport vehicles part in the evening rush-hours constitute ~9% from the transport flow along the following streets: 13. Janvāra, 11. Novembra and Krasta.

We can estimate from the research data that at present the JSC "Riga International Coach Terminal" is an important passenger transit hub that must provide inhabitants of Riga and passengers outside Riga with passenger transport services.

However, it is essential to improve the linkage with other means of transport. If in case with the railway station and the city passenger transport the linkage is marked and in the nearest future, due to the city transport infrastructure development, it will grow, then in case of the airport and port, the passenger transfer possibilities in future should be improved significantly.

If we consider the coach terminal's strategic location, the main argument today is to provide passengers with comfortable, quick access and transfer using a bus or any other means of transport.

Taking into account the demands of passenger transport and the development of Riga transport infrastructure, it is planned to develop public transport service in the following territories of Riga [2]:

1. Form out of town multi-modal transport hub (coach terminal-railway-Riga passenger terminal-airport);
2. In addition to the existing Riga International Coach Terminal, develop a new system of passenger services from three territories located in the buffer zone of Riga historical centre:
    a. Close to Maskavas-Turgeņeva Streets – the town's public transport interchange hub. Necessary territory is approx. 1.3 ha;
    b. Vienības Gatve – regional coach terminal. Advisable territory is about 1.9 ha (28 platforms, coach terminal's building);
    c. Skanstes Street – advisable territory is about 1.2 ha (17 platforms, coach terminal's building).

3. Opportunities of Logistics Development

By definition a coach terminal is a linear construction consisting of specific buildings, platforms and a territory for the rendering of services to passengers and coaches during the routes. To ensure an effective operation of such a linear construction, to be able to render high quality services both to passengers and to haulers in conformity with their needs, the functions and operational activities of a coach terminal have to be evaluated at a larger scale. We would like to suggest considering a coach terminal as ***a hub of logistics*** [7, 8], taking the operational and development model of the JSC "Riga International Coach Terminal" as a basis.

The structure of the public transport sector has been changing in recent years with a move towards privatisation through Public Private Partnerships (PPP). In trying to bring the public and private sectors together, the government hopes that the management skills and financial acumen of the business community will create better value for money for taxpayers. The objective of the development concept of the JSC "Riga International Coach Terminal" is: "To develop the JSC "Riga International Coach Terminal" as a new passenger modular transfer and service point meeting the future requirements for high culture and diversity of passenger servicing and inter-linking with other types of public transport – the railway, urban public transport, sea port and airport".

To develop an effectively operating hub of logistics, there has to be an assessment of the main critical factors for the successful operation of such a hub: location, support by government labour forces, etc. (see Figure 3).

Passenger Logistics Hub (PLH)

Strategic location	**Support by government**	**Logistics infrastructure services**	**Partnership. Opportunities of logistics development**	**Quality of labour force**	**Development of information technologies**
- Market share; - Location	- Regulation of entrepreneurship; - Tax legislation; - State aid (grants, recovery of losses);	- Technical characteristics of a coach terminal; - Possibilities of inter-modal transfers; - Level of services;	- Co-operation with haulers; - Co-operation with public authorities regulating haulers; - Co-operation with other stakeholders, (Travel agencies, service providers etc.)	- Training of personnel; - Management of human resources; - Ensuring high quality services;	- IT and telecommunication infrastructure; - WEB based easy interface; - E-commerce platform;

Figure 3. *Critical factors for Logistics Hub*

JSC "Riga International Coach Terminal" co-operates with 49 hauler companies and 2 travel agencies, including the concluded co-operation agreements with 20 passenger hauler companies engaged in international transfers, from them 11 are foreign companies. 13 foreign countries are the destination of coaches from Riga International Coach Terminal. Breakdown of routes by types and directions are characterised by the information in Table 2 [3].

Table 2. Average number of routes per day and breakdown by directions (at the rush-hours in 2006)

Routes	**Average number of routes per day**						
	Total number per day	**7:00–8:00**	**8:00–9:00**	**9:00–10:00**	**16:00–17:00**	**17:00–18:00**	**18:00–19:00**
International	60	5	7	1	6	5	7
Long-distance	471	25	35	37	43	48	43
Regional	39	1	1	1	1	6	1
Total	**570**						
By directions:							
- Kurzeme	112	6	4	7	9	13	8
- Zemgale	214	14	20	16	15	16	15
- Vidzeme	104	6	16	10	15	19	18
- Latgale	140	5	3	6	11	11	10

The international routes constitute only 8% of the total number of the serviced routes of the coach terminal, however for the strategy of coach terminal's operation the development of the coach terminal as an international point of logistics and transfer is of significant importance.

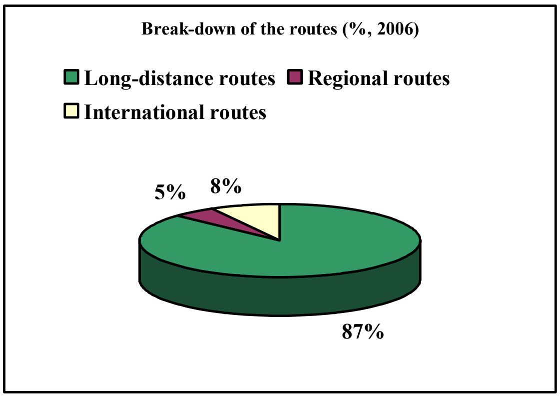

Figure 4. *The distribution of routes in the Riga International Coach Terminal*

The Riga International Coach Terminal has now developed into a significant international traffic infrastructure object of a previous coach terminal on the outskirts of the USSR. Such political and economical factors as

- accession of the Republic of Latvia to the EU;
- development of travel industry;
- movement of labour force;
- Visa facilitation, e.g. non-Visa entry for the EU citizens to the Ukraine etc., considerably increases the demand for international traffic. Even such factors as the operation of low-fare airlines, creating as if a competition for the international coach transfers of passengers, to certain extent enhance the promotion of coach traffic from those regions where there still do not exist the services of such low-fare airlines. Within the area of international transportation of passengers it is important to develop the transfer opportunities, and not just from one coach route to another, but to merge it with other types of passenger transport.

The Riga International Coach Terminal is a member of the Pan European Association of Coach Terminals, and one of the main objectives of this Association is to develop the logistics service within the area of passenger transportation for both passengers and haulers.

All the above listed factors are of great importance for effective planning of coach terminal's operations, and to ensure in future the perception of a coach terminal as a centre of logistics.

4. The Law Basis of Coach Terminal Operation

According to PLH concept, the most significant factors are the state and municipality support, including regulation of the coach terminal operation based on the normative acts of the Council of Ministers.

Public passenger transport and the relevant infrastructure development is one of the state's economic and social development indices. Due to this, the role of the state and local authorities in the solution of the matters is significant. Important changes in the regulation of passenger transportation according to the EU directions and attitude takes place in our country today. The operation of coach terminals is an entrepreneurship regulated by the state. In 2007 the state adopted new essential normative acts that regulate the operation. First of all, the law on the public transport and the relevant regulations the Council of Ministers, as well as the Regulations No 846, 11.12.2007 of the Council of Ministers of the Republic of Latvia on the registration order of coach terminals, on the mandatory services provided in the coach terminals and the order of buses' arrival, departure and parking in the territory of coach terminals are issued according to Transport Law, Article 33, Parts 5 and 6.

The Regulations No 846 of the Council of Ministers of the Republic of Latvia determine the registration order of coach terminals, the mandatory services provided in the coach terminals and the order of buses' arrival, departure and parking in the territory of coach terminals.

JSC "Riga International Coach Terminal" has to provide the following obligatory services [9]:

- use of platforms and placement of information on coach departures on the platforms (platforms are coach stopping places, separated from the general communication route, meant for comfortable and safe passenger boarding in and out of the coach);
- information on bus timetables, actual bus departure and arrival times, bus tickets and other travel document prices, number of seats and comfort level of the bus, other services provided in the bus, passenger and luggage transportation, also other information connected with passenger transportation services. This information has to be easily available and clear to the visitors of the Riga Coach Terminal. The information, acquired by the transport provider, is issued after being received from the according transport provider;
- sales of travel tickets and luggage tickets at cash-desks of the Coach Terminal;
- dispatcher services (dispatcher provides operational information about the actual departure and arrival times and seats in the bus station, bookkeeping of the actual departure and arrival times);
- maintenance of the Coach Terminal and access to it, if the operating time of the Coach Terminal is different from departure time. The Coach Terminal must be equipped with a number of seats, which corresponds to 5% of the average arrived coach seat number per hour, but not less than 10 seats;
- hand luggage, as well as lost hand luggage preservation found in the Coach Terminal;
- a possibility to use toilets, and provide place for child nursing and mother care;
- parking-place before and after the voyages, as well as between the voyages, in the territory, if technical possibilities of the Coach Terminal allow.

It is essential that the mentioned above rules provide prices for the services of the Coach Terminal [9].

Optional activities of the Coach Terminal must provide a separate inventory of the inland services provided both of income and expenses. The director of the Coach Terminal defines the total expense methodology in the accounting documentation of the organisation (proportional distribution and expense methods), following these criteria:

- direct expenses are attributed to the planned number of voyages, which has been requested or given rights to provide the services of the public transport by the transport providers (liabilities);
- general (indirect) expenses are distributed between methods of optional activity (directions), attributed to the gained income and indirect expenses, which are determined for providing of services in the field of public transportation, attributed to the planned number of voyages of the customer.
- The costs of the provided services of the Coach Terminal for the next financial year are defined, using the following formula:

$$C_k = \frac{I_{kop} + P}{N_{seats}} * AI,$$

where

C_k – cost for the services provided by the Coach Terminal in the specific category of a coach;
I_{kop} – total expenses of maintenance of the Coach Terminal, connected with capital investments;
P – planned income of the next financial year;
N_{seats} – planned number of the passengers (planned amount of coach seats per year) correspondingly to the categories of voyages provided by the customer;
AI – coach capacity (number of seats).

Therefore defining the price for services, it is possible to take into account the following criteria:

- market conditions of services of public transport, optimal maintenance requirements of the Coach Terminal, permit possibilities of the Coach Terminal, enhancement of the quality provided, geographical position, standard requirements;
- disposition of the services, time, speed and frequency;
- Coach Terminal technical and physical peculiarities of infrastructure, Coach Terminal depreciation level;
- additional services of the Coach Terminal;
- maintenance and development expenses of the Coach Terminal, movement organisation and providing expenses;
- Coach Terminal management expenses.

5. Logistics, Infrastructure, Services as Key Factor of PLH

One of the main conditions in the activity of the bus station is providing its service range volume and quality, as it has been mentioned in the previous section. Its development is influenced by both EU standard acts, as well as good practice experience. The company has also take into account the growing level of passenger requirements and to comply with the passenger rights.

It is of great importance for running a coach terminal to have internal logistics of its operation, the level of infrastructure, the variety and quality of services rendered. The most significant preconditions are characterised by the following.

Access Possibilities

1. For passenger buses and coaches
   1.1. access roads (streets);
   1.2. location of getting on/getting off platforms;
   1.3. possibilities of parking between routes;
   1.4. possibilities of coach manoeuvring.
2. For participants of external traffic: pedestrians, bicyclists, taxis, users of personal cars, urban public transport
   2.1. pavements, crossings;
   2.2. access roads;
   2.3. organisation of getting on/getting off;
   2.4. parking places.

3. For passengers in the coach terminal
   3.1. for entrance and exit and getting on/getting off platforms;
   3.2. traffic/passenger flow to and fro the platforms;
   3.3. the access to coaches (getting on, getting off, location of luggage, assistance to disabled persons, etc.);
   3.4. transfer and crossing to other vehicles;
   3.5. a plan of the coach terminal, organisation of passenger servicing, compliance with the demands of capacity;
   3.6. possibilities of travel tickets reservation/purchase (at the coach terminal, distance reservations and purchases – via agencies, Internet).

Content and Layout of Information

1. General information on availability of services;
2. Information about coach routes/destinations, interim stops, potential alternative solutions;
3. Information about the coach time schedules at destinations, at interim stops, about the duration of travel, accuracy of compliance with the time-table;
4. Information about the travel costs, about possible cost relieves, bonuses. Order of ticket reservation and sales, various options of payment as well as the options of cost compensation in case of travel cancellation;
5. Information about ancillary services, e.g. movement of luggage, its storage, use of the waiting lounge (waiting lounge or rest rooms) in case of transfer from route to route, etc.
6. Information about physical assistance to disabled persons, persons with children;
7. Information about the rights and obligations of passengers.

Comfort

1. Quality of air, air-conditioner operation, temperature regime within the premises of the Terminal;
2. Sheds, elevators, staircases, escalators;
3. Ensuring clean environment;
4. Convenient lighting;
5. Noise isolation;
6. Waiting rooms, seats;
7. Premises of individual hygiene (toilets, showers, rooms for mothers and children);
8. Other services: ensuring communication services; services of public catering and trade; possible options for pastime etc.

Security/Protection

1. Video surveillance;
2. Presence of security officers;
3. Easy-to-locate first aid office;
4. Prevention of pollution;
5. Measures to prevent various risks (fire security, prevention of terrorism, preventive measures against accidents, etc.

6. Information Technologies as an Important Factor of Successful Development of Passenger Logistics

It is necessary to form and develop the information system (IS) of the coach terminal more efficiently in order to optimise the operation of the coach terminal, to improve the work with haulers and to make the services of the coach terminal and carrier companies more comfortable for passengers, thus providing a better access to coach and bus transport services.

The development of information technologies that includes the IT and telecommunication infrastructure, the WEB based easy interface and an e-commerce platform allows to ensure access to both the passengers and hauler companies, thus widening the range of the coach terminal operation and services.

Information System ”Baltic Lines” used by the coach terminal was developed in 2003 and was introduced in all bus terminals in Latvia in 2004. The information system collects, processes, stores, analyses and disseminates the information providing the following principal functions [10, 11]:

- coach timetable and operative information about the changes;
- information about the coach movement – arrival, departure, location at the platforms, delay;
- ticket reservation and sales system, including:
    - planning of routes, using services of several hauler companies and vehicles;
    - different ways of payment and communication;
- observation of passenger rights in accordance with normative documentation;
- management and control system of the coach terminal's service processes;
- processing of operational information in economic activity accounts;
- and control.

In order to ensure these functions, the coach terminal must process a large amount of operatively changing data coming from multiple sources of information, both internal and external. The data processed in the system is exported both for the internal use at the enterprise and to external users. The information flow is depicted on Figure 5.

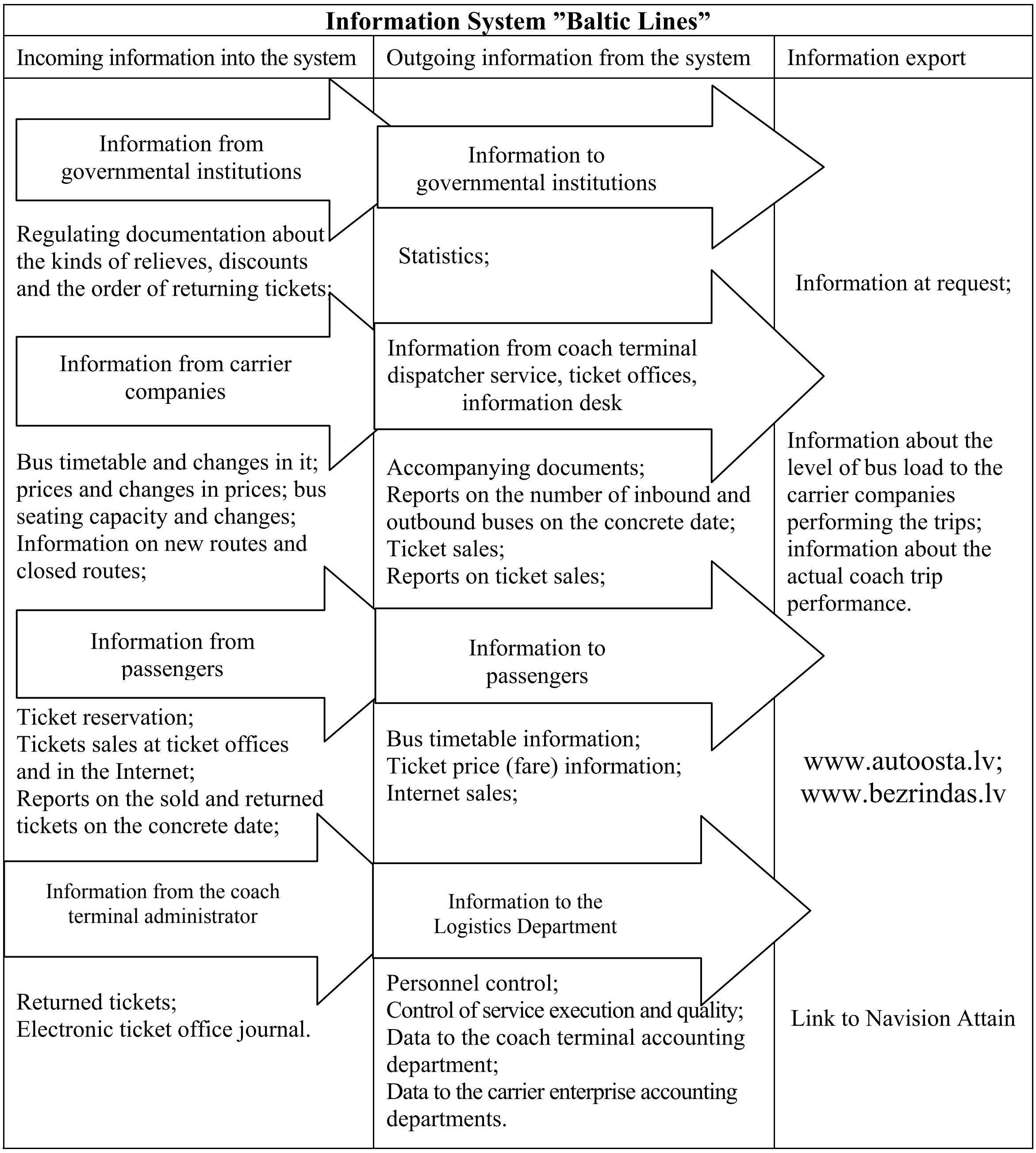

***Figure 5**. The information system's information flows of the coach terminal*

In 2007, following information technology possibilities, JSC “Riga International Coach Terminal” and its partners JSC “Mikromaksājumi” and JSC “Baltijas Transporta Informācija – BTI” have implemented bus ticket sales in the Internet. www.bezrindas.lv (bus tickets on the web across Latvia). Although not all service providers are ready to implement such service, due to difficulties in the training of coach drivers, ticket sales in the Internet are growing and the total amount of sold tickets in 2007 was 19604 tickets. On December 1.4% of all tickets sold by JSC “Riga International Coach Terminal” were sold in the Internet, and the growth pace is increasing, which is showed on Figure 6.

A ticket can be bought online by printing it immediately (immediate print out), and sending by e-mail; in the nearest future it will be possible to receive it as a text message to a mobile phone or by simply remembering ticket ID number and naming it to the coach driver.

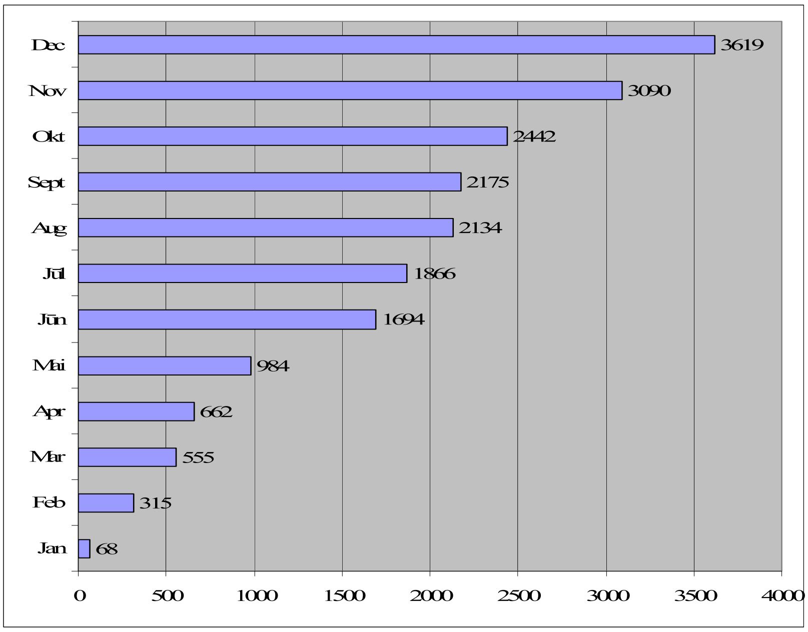

Figure 6. *Tickets bought in the Internet (RIBT, 2007)*

To use e-ticket, the passenger needs an ID, which can be asked by the driver to verify its data by bus passenger list.

The coach terminal’s information system is created to fulfil all the principal functions described in the work. The principal peculiarity of the information system lies in its diversity both from the points of information character and business interests (see Figure 7).

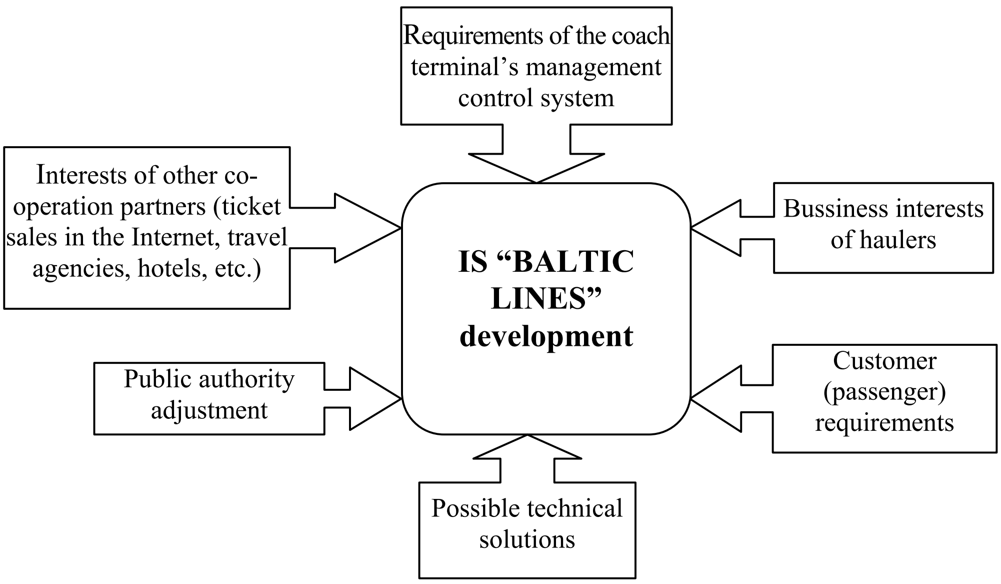

Figure 7. *The interests of the users influencing the development of the coach terminal’s information system*

Although the information system's principal function is to provide the coach terminal's daily operation of carrier and passenger service, it includes the functions of tactical planning and control, as well as the strategic planning. The development of the system is determined by the requirements of the users and changes in the business environment.

Strategic planning

The State LLC "Road Transport Administration" with the help of the "Baltic Lines" system performs the control of passenger transport implementation. The character and amount of information is sufficient to be used in making strategic decisions – on the further route network development and forming of the state order in passenger transport. The coach terminal's management, certainly, plans the terminal's future long-term economic activity by adopting strategic resolutions on the further market, the existing and new service development building them on the data of information system of the coach terminal. The determination of organizational objectives is also within the scope of strategic planning.

The further logical development and improvement of the program "Baltic Lines" is performed by the VSIA "Autotransporta direkcija", forming a unified public transportation ticket sales, reservation and accounting system.

The formation and the maintenance order of this system is defined in the Regulations on 02.10.2007 "Regulations on unified public transport ticket sales, advance booking and accounting system creation and support" by Cabinet of Ministers of the Republic of Latvia [12].

Such system is created and supported in order to:

- accumulate and summarize information on existing routes of the route network, determined travel costs (tariff), public transport time tables, stops, transportation providers, coaches involved in passenger transportation and other conditions, which have been defined according to standard acts, as well as public transport services client contracts or contracts on service providing in the route network (on a route) (e.g. availability with levied conditions, availability for people with functional disabilities, people with kids (babies in perambulators as well), oldsters);
- receive, process and actualise information in real-time about system user purchasing, advance booking and taxes used in accounting; as well as other information on payment registration electronic devices and equipment considering ticket sales, advance booking and cancellation in ticket boxes and public transport vehicles;
- receive and process information in real-time on global positioning and telematic devices mounted in public transport vehicles of transportation providers. The information considers bus position coordinates and coordinates of ticket sales places;
- receive, accumulate and actualise information on unplanned changes or events (e.g., rescheduled departure or arrival time of a public transport vehicle, cancelled or additional voyage, or any other changed provision, which has been defined in public transport services client contracts or contracts on service providing in the route network (on a route).

The current developing task in this system is the development of the system of quality indicators on the base of sampled data from IS "Baltic Lines". One of the indices is punctuality index [14]. This index indicates the magnitude of time gap between actual and scheduled arrival times. The realization of this task will give the possibility to analyse the reliability of the bus service and to improve the level of quality on the base of these results.

7. Decision-Making about Location of a New Coach Terminal with Models

The location of the coach terminal in the centre of Riga next to administrative, trade, cultural and educational centres is big advantage for the passengers. An additional advantage is the location of the coach terminal next to a railway station, close to the sea port and at a convenient distance from the airport, as well as with easy access to the urban public transport network.

However, one of the most serious critical factors for a sustainable future development of the coach terminal is the insufficient space of the territory for further development of the terminal. During the peak periods the coach terminal is already operating close to the limits of its capacity. Another critical factor for the activities of the terminal are traffic jams in Riga, having negative impact on the compliance with the timetable of coach arrival and departure.

After the assessment of the development of Riga transport system in future and the potential increase of the number of coach passengers, the experts ("Imink" Ltd) recommend to develop the sites for route destination of public transport at several locations in Riga, developing for passenger transport routes entering and leaving Riga a multi-modal transport hub on the outskirts of Riga: the coach terminal-railway-Riga passenger sea port-airport "Rīga", as well as to add the transfer functions to the Riga International Coach Terminal functions also.

To increase the carrying capacity of the Riga Coach Terminal according to the amount of the passenger flow, to the supply of services to passengers on the outskirts to develop an additional new system – from three territories located in the buffer zone of Riga historical centre.

One of the support points of the Riga International Coach Terminal is a new coach terminal under development in Riga, Pārdaugava, on Vienības Gatve 6. The territorial location of the land plot is close to the railway station "Torņakalns", next to a newly developing administrative and cultural centre of the city. There is a possibility to develop a rather convenient transfer from buses and coaches to the urban public transport.

The critical factor could be the necessity to transfer to other means of public transport to get to the city centre. The coach terminal to be developed is not equally advantageous for all geographic directions of coach routes. The said negative factors are the main reasons for the determination of servicing sector of a new coach terminal – the coach routes from Kurzeme and Zemgale, according to the priorities of transport organisation in Riga.

A new coach terminal will ensure the possibility to implement the necessary reconstruction of the central coach terminal on Prāgas Street 1, having the temporary solution for servicing of coach routes on Vienības Gatve.

The selected method for analysing the offered decisions can be mentioned a simulation modelling The most important benefits of modelling in decision-making are the cost of mistakes much lower in virtual experimentation and modelling allows the analysis and comparison of a very large number of possible alternative solutions. The availability of a simulation model at the pre-planning and planning stages will allow analysing the possible design solutions and finding out an optimal one.

There is the framework for decision-making with models on Figure 8. All stages of this process are important but we are paying a special attention to two stages: forecast planning variables and monitoring function. In order to test the solutions it is necessary to estimate the inputs to the model. It concerns knowing not only current values of these variables but also estimating the future values of these inputs. These forecasts have to use the future scenarios of territory development and are the object of other serious analysis and modelling. A monitoring function is the additional detail to standard process of decision-making with models [15]. This function is the key moment in improving the models. It concerns that the data, which can be requested additionally, models that can be reconstructed according to changing the strategy and so on. This adaptive decision-making is more flexible and can take into account the fast changing situation in transport system in total.

Simulation generally refers to a technique for conducting experiments (such as "what-if") with a computer on a model of a studied system.

Advantages of simulation are the following:

- allows including the real-life complexities of problems; it is descriptive;
- can handle an extremely wide variation in problem types;
- can show the effect of compressing time;
- can be conducted from anywhere.

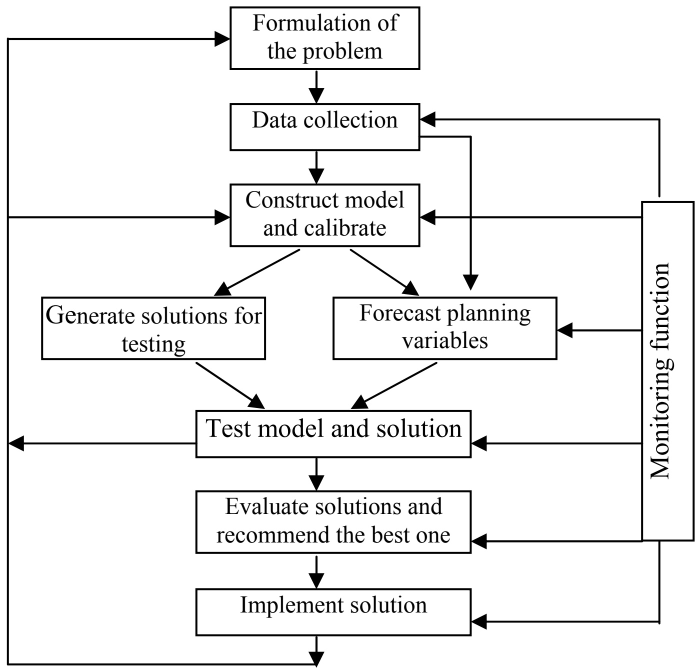

Figure 8. *Planning and monitoring with models*

So, the simulation model was used for the stage of new transport node (Coach Terminal) planning.

The objective of modelling was to develop a transport traffic diagram within the territory of the coach terminal, then adding to it the diagram of foot traffic (pedestrian movement) and the diagram of vehicles' traffic in the surrounding environment of the terminal. The design of a new coach Terminal is presented on Figure 9.

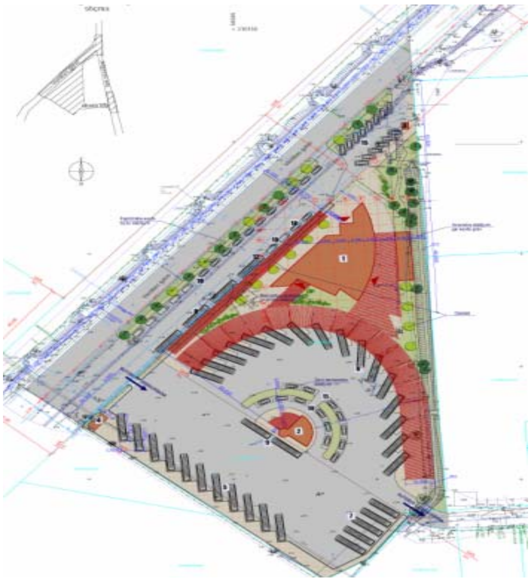

Figure 9. *Plan of a new Riga Coach Terminal on Vienības Gatve Street in Pārdaugava*

The process of model constructing on the basis the simulation package VISSIM, details of simulation model and making an experiment with it are described in the article [16]. It is noticed that in general a new coach terminal is able to provide the current schedule. However, the experiments with simulation model have shown that the scheme of transport vehicles' exits from the coach terminal territory suggested for today is not optimal and leads to a queue formation (Fig. 10). In the process of a model construction and its operation analysis the recommendations for the coach terminal design changes are suggested that results in the change of the bus station plan project taking into account the determined disadvantages.

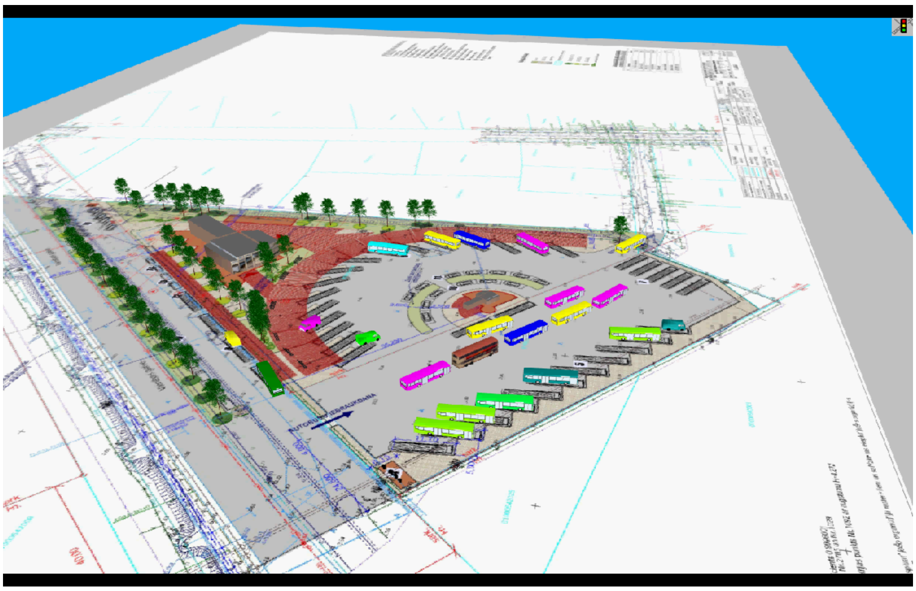

Figure 10. *The simulation model of a new coach terminal*

All the mentioned factors are significant to develop the coach terminal into the Passenger logistics hub while planning the further development of passenger infrastructure objects. As it is already stated at the beginning of the article, the construction of several new coach terminals in Riga is being planned in the nearest time. Due to this, it is very essential to anticipate in good time the scenarios of development and the possible risks in the design, development and future exploitation of the objects.

7. Conclusions

The development of passenger transport infrastructure is a significant factor of passenger transport. It is essential to provide inter-modal interchange possibility when planning the location and construction of further coach terminals and other transport infrastructure objects in the city and construction.

The approach to Coach Terminal as a passenger logistics hub is considered and all factors which are important for it are discussed.

The most attention is paid to using of information technologies on the operating and strategically levels of coach terminal management.

The example of simulating model using on decision-making stage is described.

The engineering approach to logistics and transportation implies mathematical modelling and computers-based solutions to optimise the decision-making process. During the development of the modelling the critical points are identified and decisions are taken to reduce the risk of their occurrence.

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- Associate Professor of Baltic International Academy (Latvia, Riga);
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- **Scientific activities**: electronics and telecommunication, transport telematics and logistics, radar technologies

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- **Scientific activities:** applied statistical analysis, modelling and simulation

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- **University study:** Mg. sc. ing., Riga Technical University (1997)
- Master Degree in Economics, University of Latvia (1980)
- **Publications:** 5 publications
- **Scientific activities:** public transport logistics

Ella Ivanova (born in Russia, December 3, 1968)

- **University study**: Riga Civil Aviation Engineering Institute (1987-1992)
- **Publications:** 2 publications
- **Scientific activities:** telemedical systems

CUMULATIVE INDEX

TRANSPORT and TELECOMMUNICATION, Volume 8, No 2, 2007 *(Abstracts)*

Olegas Prentkovskis, Alfonsas Daniūnas, Romualdas Kliukas. Study Programmes in Transport Engineering and Telecommunication Engineering: Attractiveness among Applicants to Lithuanian Universities, *TRANSPORT and TELECOMMUNICATION,* Vol. 8, No 2, 2007, pp. 4–13.

The operation of industrial, construction and agricultural enterprises as well as work efficiency and public opinion largely depends on reliability and effective performance of transport and telecommunication. The qualified specialists of Lithuanian universities educated in transport engineering and telecommunication engineering are highly appraised in the European Union countries and others countries. The present paper deals with the higher education system of Lithuania, also describes a system of joint admission to Lithuanian higher schools, which is being already used for several years in this country. The problems of selecting applicants to the Lithuanian universities and the level of knowledge of the applicants admitted to study the programmes in transport engineering and telecommunication engineering, and other study programmes are also discussed in the present paper.

Keywords: Lithuanian higher schools, universities, higher education, applicants, joint admission, transport engineering, telecommunication engineering, study programmes, popularity, competitiveness index, motivation index

Irina Arlyukova. Macroeconomic Regulation of Air Transportation Market under Modern Economic Conditions, *TRANSPORT and TELECOMMUNICATION,* Vol. 8, No 2, 2007, pp. 14–19.

The article deals with modern problems of functioning of air transportation market. Macroeconomic regulation is considered as the factor having an essential influence on the state of air transportation market and the level of profitableness of modern airlines. Priority directions of macroeconomic regulation from the positions of providing of the functioning of effective air transportation market are determined. Possible state participation forms in airlines activity are analysed.

Within the limits of the article special attention is paid to the problems of state risk-management in the sphere of air transportation. Main macroeconomic risks, which are necessary to be considered in the limits of modern airlines risk- management, are determined.

"Human factor" importance in providing of the functioning of effective air transportation market including the provision of aircraft activity safety is underlined. The personnel motivation problems under "force-majeure" circumstances are considered and the necessity of state and private investors' participation in the formation of social guarantees to modern airline personnel is determined.

Keywords: air transportation market, risk, risk-management, state regulation, profitableness, safety, personnel guarantee, motivation

Ella Ivanova. Patients' Mobility And Access to Information of Medical Services, *TRANSPORT and TELECOMMUNICATION,* Vol. 8, No 2, 2007, pp. 20–27.

This paper deals with information systems support of the process, which is to provide medical services to patients without reference of their residence and the location of medical service centre. In conditions of increasing mobility it is necessary to find the ways of quality and efficiency improvement while providing medical services. Special attention is paid to questions, which show the index of information and services access in Latvian medical cluster. Choice of criteria and indices of telemedical project financial-economic evaluation, are being considered.

Keywords: mobility, service, accessibility, telemedical systems, unified information zone

Yekaterina Trofimova. Multilateration Error Investigation and Classification. Error Estimation, *TRANSPORT and TELECOMMUNICATION,* Vol. 8, No 2, 2007, pp. 28–37.

The MLAT errors have their origin at TDOA measurement errors, as primary input information. These errors can be distinguished by many different criteria. The basic criterion is mechanism of error origin, for example. Under this criterion the errors can be split into the main categories – temperature

TRANSPORT and TELECOMMUNICATION, 8.sējums, Nr.2, 2007 (Anotācijas)

Oļegs Prentkovskis, Alfons Daniūnas, Romualds Kliukas. Mācību programmas transporta inženierijā un telekomunikāciju inženierijā: Lietuvas universitāšu atraktivitāte starp reflektantiem, *TRANSPORT and TELECOMMUNICATION*, 8.sēj., Nr.2, 2007, 4.–13. lpp.

Industriālo, būvniecības un lauksaimniecības uzņēmumu darbība, kā arī darba efektivitāte un sabiedriskais viedoklis lielā mērā ir atkarīgs no transporta un telekomunikāciju darbības efektivitātes. Lietuvas universitāšu kvalificētie speciālisti, kas ir specializējušies transporta inženierijā un telekomunikāciju inženierijā ir ļoti pieprasīti speciālisti Eiropas Savienības valstīs, kā arī citur pasaulē. Raksta autori izskata jautājumus par augstākās izglītības sistēmu Lietuvā, kā arī apraksta apvienoto uzņemšanu augstākajās mācību iestādēs Lietuvā, kas jau vairākus gadus sekmīgi darbojas.

Atslēgvārdi: Lietuvas augstākās mācību iestādes, augstākā izglītība, reflektanti, apvienotā uzņemšana, transporta inženierija, telekomunikāciju inženierija, mācību programmas, kompetences rādītājs, motivācijas rādītājs

Irina Arļukova. Gaisa pārvadājumu tirgus makroekonomiskā regulēšana mūsdienu ekonomiskajos apstākļos, *TRANSPORT and TELECOMMUNICATION*, 8.sēj., Nr.2, 2007, 14.–19. lpp.

Rakstā autore risina mūsdienu aktuālo problēmu – gaisa pārvadājumu tirgus darbība. Makroekonomiskā regulēšana tiek uzskatīta par tādu faktoru, kam ir īpaša ietekme uz gaisa pārvadājumu tirgus stāvokli un ienesīguma līmeni mūsdienu aviolīnijās. Tiek noteikti makroekonomiskās regulēšanas galvenie virzieni, no gaisa pārvadājumu tirgus efektīvas funkcionēšanas viedokļa.

Rakstā tiek analizētas iespējamās valsts institūciju dalības formas aviolīniju darbībā. Bez tam autore īpašu vērību velta arī tādam jautājumam, kā valsts riska vadība gaisa pārvadājumu sfērā, tiek noteikti galvenie makroekonomiskie virzieni mūsdienu aviolīniju riska vadībā.

Rakstā tiek iztirzāts arī cilvēka faktora nozīmīgums, nodrošinot efektīvu gaisa pārvadājumu tirgus darbību. Personāla motivācijas problēmas "fors-mažora" apstākļos, kā arī valsts un privāto investoru dalība moderno aviolīniju personāla sociālo garantiju veidošanā tiek uzsvērta dotajā rakstā.

Atslēgvārdi: gaisa pārvadājumu tirgus, risks, riska vadība, ienesīgums, drošība personāla garantijas, motivācija

Ella Ivanova. Pacientu mobilitāte un informācijas pieejamība mūsdienu medicīnas pakalpojumu sfērā, *TRANSPORT and TELECOMMUNICATION*, 8.sēj., Nr.2, 2007, 20.–27. lpp.

Rakstā tiek iztirzāts jautājums par pacientu medicīnas pakalpojumu pieejamību ar informācijas sistēmas palīdzību, neskatoties uz pacientu dzīvesvietu un medicīnisko centru atrašanās vietu.

Īpaša uzmanība tiek vērsta jautājumiem, kas parāda informācijas indeksu un pakalpojumu pieejamību Latvijas medicīnas jomā. Telemedicīniskā projekta finansiāli ekonomiskā izvērtējuma rādītāji un izvēles kritēriji tiek analizēti.

Atslēgvārdi: mobilitāte, serviss, pieejamība, telemedicīniskā sistēma, unificēta informācijas zona

Jekaterina Trofimova. Kļūdas multilaterācijas jeb hiperboliskās pozicionēšanas izpēte un klasifikācija. Kļūdas novērtējums, *TRANSPORT and TELECOMMUNICATION*, 8.sēj., Nr.2, 2007, 28.–37. lpp.

MLAT (hiperboliskā pozicionēšana) kļūdām ir to izcelsme TDOA mērījumu kļūdās, kā sākotnējā informācija. Šīs kļūdas var būt iedalītas pēc ļoti daudziem un dažādiem kritērijiem. Pamata kritērijs, piemēram, ir kļūdas izcelsmes mehānisms, Pēc šī kritērija kļūdas var būt sadalītas galvenajās kategorijās – temperatūras atkarība un HW komponenta nolietošanās. Šajā rakstā autore veic mērķa lokalizācijas kļūdas analīzi, lietojot multilaterācijas sistēmu.

Atslēgvārdi: multilaterācija jeb hiperboliskā pozicionēšana, akurātums, kļūdas

Mihails Savrasovs. Liepājas pilsētas makroskopiskā modeļa lēmuma pieņemšanā attīstība, *TRANSPORT and TELECOMMUNICATION*, 8.sēj., Nr.2, 2007, 38.–46. lpp.

Transporta infrastruktūras izmaiņu gadījumā vissvarīgākās lietas ir transporta plūsmu sadale pilsētas transporta tīklā, to izvērtēšana un paredzējums. Autors rakstā parāda piemēru, lietojot makroskopisko modelēšanu lēmumu pieņemšanā, izmainot transporta infrastruktūru. Šīs izmaiņas ietver sevī gan jauno tiltu izbūvi pāri dzelzceļam, gan jaunu ielu būvniecību.. Tas viss prasa lielas investīcijas, un līdz ar to šo darbu pamatā ir efektivitāte un atdeve.

Atslēgvārdi: makroskopiskā modelēšana, lēmumu pieņemšana, VISUM modelis

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