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Increasing capacity of infrastructure for public transport co-modality and sustainability in cities

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ABSTRACT

The article describes public transport co-modality for sustainable development of a public transport system. New strategies are needed to make the city public transport more efficient, more accessible and more sustainable. There are some concepts described in the article. The concepts are illustrated with practical examples – how it is possible to increase the capacity of infrastructure and what has been done in the city of Riga for public transport sustainable development. Key benefits of each concept are also described. A more efficient use of city space, allocated to transport improves the overall performance of all the passenger transport system. The paper presents the concept of aid – a base graph approach to calculate the territory assigned to the particular stop of public transport for the cost optimization. Efficient planning and better use of infrastructure, as well as passenger-friendly interchanges and good traffic management, allocated to public transport, bring the public transport system towards sustainability.

KEYWORDS: infrastructure, sustainability, city transport system, public transport, co-modality, aid – base graph approach

1. Introduction

The social importance of urban passenger transport is indisputable. Moreover, the external effect generated by urban passenger transport is not confined to the city, and has an impact on the socio-economic development of the region and even of the country. The urban passenger transport is an essential component of any economy because the population need for public transport is very high.

Public passenger transport plays a leading role in municipal transportations in Riga. They are served by 54 bus, 20 trolley-bus, and 11 tram routes. The public transport system includes also taxis, trains in the city, and recently developed a system of public bicycles.

In recent years, characterized by a high rate of motorization of the population, the social significance of public transport has been increasing. Negative consequences of the increasing number of private cars on the streets include traffic jams, pollution, security problems, and lack of parking places. Such problems are solved in the world by upgrading public transport, development of the street network, taking into account the provision of its priorities, and selected lanes based on the structure and the technical level of the vehicles.

The team of Institute of Electrical Engineering and Electronics has a broad experience in the development of new technological solutions as well as in providing the expertise to the Transport Department of the city of Riga council on public transport services.

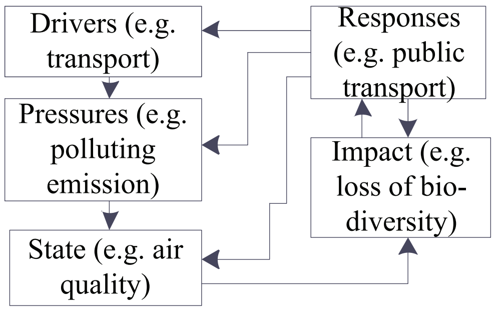

Fig. 1. DPSIR approach and the interactions of its elements Source: [6]

The recent developments comprise solutions for recuperation of braking energy of trams, the use of an ITS solution [1], the design of bi–directional DC substations [2], the formulation of ITS concept for the city of Riga [3], and the technical expertise in the Transport Department of the city of Riga council, including preparation of new ideas as student proposals for an international competition of Transport department, as well as development of decision making procedures for transport via participation in COST 356 project [4].

2. Concept of sustainability

The allocation of indicators to the three pillars of sustainable development, i.e. to its economic, social or environmental dimension is well known [4]. Of course, in many cases this distinction cannot be clearly made, as several indicators represent more than one dimension or it is not easy to unequivocally assign them.

An extension of the DPSIR-approach has been recommended by Niemeijer and de Groot [5]: They pledge to use an enhanced DPSIR framework, a so called 'eDPSIR', that does not consider individual causal chains, but looks '…at causal networks in which multiple causal chains interact and inter-connect'.

The DPSIR indicator framework is an extension of the PSR model developed by the Organisation for Economic Co-operation and Development [7].

The balance between the requests for transportation, transport costs, quality of service [8], including environmental impact is a classical logistic task relevant to the transport service. Normally the changes in transportation in the cities are relatively slow, due to the specific of requests for transportation and high cost of infrastructure.

In the case of very strong minimization of transport budget due to the crisis in Latvia, the need for calculations and modeling of sustainable transport system is very important, in order not to break the balance described by the DPSIR model.

3. Public transport services in Riga

The company "Rigas satiksme" provides public transport services in Riga, offers various types of transport for rent, as well as manages the parking lots of Riga municipality. From May 1, 2009, only electronic payments are accepted in Riga public transport. The company "Pasazieru vilciens" provides local railway transport services. From this year the e-tickets are used in both transport companies.

According to statistical data, public transport of "Rigas satiksme" [9] carried 133,399,525 passengers in 2010 [9]. So an average passenger flow per vehicle per day in 2010 is calculated using formula:

$$X=P/V/Y \tag{1}$$

where:

X – an average passenger flow per vehicle per day in 2010;

P – the number of passengers carried by "Rigas satiksme" in 2010;

Y – days in the year 2010 = 360.

V - the number of vehicles used by "Rigas satiksme" in 2010;

$$V=(T+t+B) \tag{2}$$

where:

T – the number of trams used by "Rigas satiksme" in 2010;

t – the number of trolleybuses used by "Rigas satiksme" in 2010;

B – the number of buses used by "Rigas satiksme" in 2010;

So, we have on average: 339 passengers per vehicle per day carried by "Rigas satiksme" in 2010.

Statistics of "Rigas satiksme" about ticket control in 2010 in Riga public transport say that there were 58,941 fare dodgers in 2010 in Riga public transport system. It is by 2,406 fare dodgers more than in 2009, when there were 56,535 fare dodgers. Just to compare: there were 471,583 ticket checkups in 2009, which is 664 less than in 2010.

Recently the company "Rigas satiksme" made a decision to strongly reduce the available services, which significantly affected the quality of service. This decision was taken based mainly on administrative and financial criteria, however, the assessment of the service quality and of the balance between requested services and available resources was not sufficiently addressed.

There is a numerical example for the calculation of sufficient number of services proposed.

Fig. 2. VPE 415 card reader
Source: [9]

4. E - ticketing

The Riga public transport (bus, trolleybus, tram, and railway) operates an electronic payment system, or e-ticket (e-talons). Every time, when entering a public transport vehicle, a passenger has to apply his/her e-ticket to the validator until the ticket's validity period and the number of remaining trips are displayed on the validator screen, the green signal lights up and a short signal sounds. Validators are located inside public transport vehicles, next to every door. In case of having no e-ticket, a passenger has to buy a one-time ticket in a public transport vehicle.

The understanding of the transport infrastructure is one of the important points for further planning. An efficient transport flows planning may improve the transport situation. It can reduce costs and travel time. For the effective transport infrastructure planning it is necessary to have the knowledge base of the current situation on the streets. Based on the received data of the current situation a deep analysis can reveal gaps and weak infrastructure sites, which need considering for early decisions.

The electronic payment system, which is based on contactless technology, recently introduced in the Riga public transport, consists of VPE 415 – card readers, which check electronic tickets, transmit the data about passengers checking-in to the driver computer and continually exercise control. A VPE 415 card reader is shown in Fig. 2.

The use of e–ticketing system is the basis for development of future optimization scenario.

5. Method of the calculations

The time, costs and quality of the service parameters are used for task optimization.

Time vs quality of service indicators parameters are defined by formula 3. The main variable and the parameters will be used next in the analysis.

$$d_{in} = \tfrac{1}{2}\,Var[D^d_{in} - D^d_{(i-1)n}] = \tfrac{1}{2}\,\{Var[D^d_{in}] + Var[D^d_{(i-1)n}] - Cov[D^d_{in}, D^d_{(i-1)n}]\} \quad (3)$$

where: Var[…] and Cov[…] - determines the difference, if D^d_{in} and $D^d_{(i-1)n}$ values are not correlated

A legend of reliable service is shown in Table 1.

The delay time is one of variables in calculating the level of service. The delay time depends on many factors: firstly on the number of passengers embarking and disembarking, secondly on emergencies on the road. Formula 4 shows the delay time calculation, dependent on the length of the vehicle and passenger volume. The calculation of traffic accidents will not be taken into consideration here.

$$D'_{in} = d' + \triangle_{d'} * d'_{in} + \triangle_{w} * Wx^{w}_{in}, \quad (4)$$

Single-door vehicle, if $d'_{in} > 0$ or $Wx^w_{in} > 0$
Single-door vehicle, if $d'_{in} = Wx^w_{in} = 0$
$D'_{in} = d' + \max(\triangle_{d'} * d'_{in}, \triangle_{w} * Wx^{w}_{in})$,
Double-door vehicle, if $d'_{in} > 0$ or $Wx^w_{in} > 0$

Table 1. Accepted parameters and variables of reliable service

	Meaning
Sp^p_{in}	Passenger occupancy during trip *i*, at the moment when the vehicle leaves stop *n*
Wx_{in}	The average number of passengers *i* coming to a stop *n*
D_{in}	The gap between journeys i and i - 1, when the vehicle leaves stop *n*
D^d_{in}	Trip time *i* difference between the departure time from stop k - 1 and the arrival time at stop n
d_{in}	The difference, which is designed to R_{ik}
D'_{in}	The delay time during trip i to stop k, includes the time which is necessary to accelerate and slow down ($D_{ik} = 0$ if it does not stop at the transport stop *n*)
d'	The delay time part includes the time which is needed to accelerate and slow down (b = 0 if it does not stop at the transport stop *n*)
d'_{in}	The number of passengers boarding vehicle i to stop k
Wx^w_{in}	The number of passengers who got out of vehicle i on stop n
$\triangle_{d'}$	Insignificant time delays in boarding
$\triangle_{w}$	Insignificant time delays in disembarking

Double-door vehicle, if $d'_{in} = Wx^{w}_{in} = 0$

Formula 4 assumes that the embarking and disembarking passenger flows in two-door vehicles will differ from the flow in single-door vehicles. Knowing the number of entries and exits, it can be expected that a significant uncertainty will not happen.

The following factors affect the delay time:

- payment form
- arrival characteristics
- the conflict between the embarkation and disembarkation
- potential free space between vehicles
- the traffic characteristics
- passenger performance.

The boarding time of passenger:
$\triangle_{d'}$ = 1.5 sec pay the conductor
$\triangle_{d'}$ = 2.5 – 3.0 sec – in cash - with residue
$\triangle_{d'}$ = 5.0 sec – with residue
$\triangle_{d'}$ = 6.5 sec – automated machines

Disembarking passengers:
$\triangle_{w}$ = 1.5 sec – without baggage
$\triangle_{w}$ = 3.0 sec – small baggage
$\triangle_{w}$ = 5.0 sec – big baggage

The delay time of the stop:
d′ = 2.0 sec – paying to conductor
d′ = 5.5 sec – possibility of free space (the vehicle can easily leave the stops, does not interfere with other traffic)
d′ = 7.0 sec – have no possibility of free space.

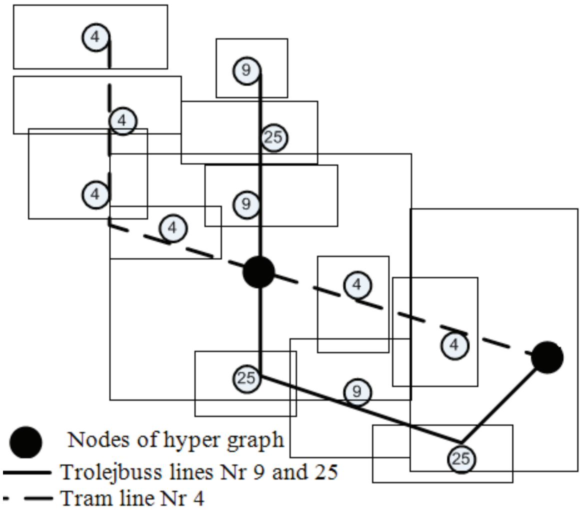

Fig.3. Principle applied to define preferential catchment areas on the fragment of hyper graph of Riga City public transport system for tram 4 route and trolley number 25 and 9 routes.

The second key variable is the journey time. The term “travel time” includes the following data: travel time from the outgoing point (origin) – a vehicle waiting time – travel time in transport – the time to destination.

The introduction of preference criteria Z [4], based on statistics available, is proposed for the calculation.

6. Catchment areas

The calculation of catchment area for a given origin--destination stop, the results of the accessibility study and rail journey times are taken into account. The so-called “preferential” catchment areas are based on the criterion of minimising the generalized travel time, which includes the time required for the actual rail journey, the time *taken to reach the station of departure and the arrival at* the final destination, plus the parking time (time to find a space to leave the car). As exemplified in Figure 3 [10], a given residential area is included in the catchment area of station 1, if it fulfils the following two requirements:

- The time required to reach stop A is less than the time required to reach stop B.
- The quality of service (preference of passenger) for stop A is more than that of alternative stops.

Lets display a public transport route network as the graph, where peaks of the graph are stations, but the routes between nodes are considered as arcs of the graph. The public transport system will consider a public transport hyper graph, where Riga (Latvia) tram 4 route from the “Botanic Garden” stop to the “Grēcinieku iela” stop $P_4^{tr}=\{ P_4^{tr}{}_1, P_4^{tr}{}_2,\dots ,P_4^{tr}{}_n\}$ and trolleybus no 9 route is $P_9^{t}=\{ P_9^{t}{}_1, P_9^{t}{}_2,\dots ,P_9^{t}{}_u\}$; hyper graph peaks in this case will be “Botanical”, “Slokas Street” and “Grecinieku street”.

The example of a public transport system hyper graph is shown in Fig. 3.

The following map shows the existing network of tram stops in Riga for tram No 4 areas.

This means that, in the same area, the catchment areas for different transport modes could be identified by preference (quality of service and price of journey).

The model is as follows:

With: $Z^1(P^{tr}{}_1)$, probability of residential area i to choose stop $P^{tr}{}_1$,
$Z^1(P^{tr}{}_2)$, probability of residential area i to choose stop $P^{tr}{}_2$,
$Wx(P^{tr}{}_1)$, number of useful direct connections of stop $P^{tr}{}_1$ for residential area i,
$Wx(P^{tr}{}_2)$, number of useful direct connections of stop $P^{tr}{}_2$ for residential area i,
$t(i\ P^{tr}{}_1)$, time of residential area i for n given trip via stop $P^{tr}{}_1$,

$t(i\ P^{tr}_2)$, time of residential area i for a stop trip via station P^{tr}_2,

$$P^{tr}_{1i\ Ptr1}=(Wx(P^{tr}_1)/\ t(i\ P^{tr}_1))\ /((\ Wx(P^{tr}_1)/\ t(i\ P^{tr}_1))+(Wx(P^{tr}_2)\ /\ t(i\ P^{tr}_2))) \quad (5)$$

$$P^{tr}_{2iPtr2}=(Wx(P^{tr}_2)/\ t(i\ P^{tr}_2),)/((Wx(P^{tr}_1)/\ t(i\ P^{tr}_1),)+(Wx(P^{tr}_2)/\ t(i\ P^{tr}_2)),$$

7. Data use

The following subsystems will be considered: 1) power system (Se); 2) transport system with vehicles (St); 3) set of passengers (Sp).

Vehicles functions, an intelligent agent system for their implementation and the enforcement of intellectual equipment are described below. Set Sp of passengers in time moments in transport system St with vehicles $S^t_1, S^t_2, ..., S^t_n \in St$, with their functions S^f_n, which provides an interface to the Advanced Traffic Management Systems, Advanced Traveler Information Systems, Advanced Public Transport Systems, Advanced Vehicle Control Systems, Advanced Rural Transportation Systems, Commercial Vehicle Operations, taking into account the environmental impact of W_v.

The following designations will be used in this article:

Se – the power system;

St – the transport system with vehicles $S^t_1, S^t_2, ..., S^t_n \in St$;

S^t_{direkt} – the minimum of vehicles, which is necessary to provide the passengers transportation;

Ste – the consumption of power resources of vehicles with its components $S^{te}_1, S^{te}_2, ..., S^{te}_n \in Ste$; n=1,2, ...,

Sp – the set of passengers with subsets $S^p_1, S^p_2, ..., S^p_k \in Sp$; k=1,2, ...,

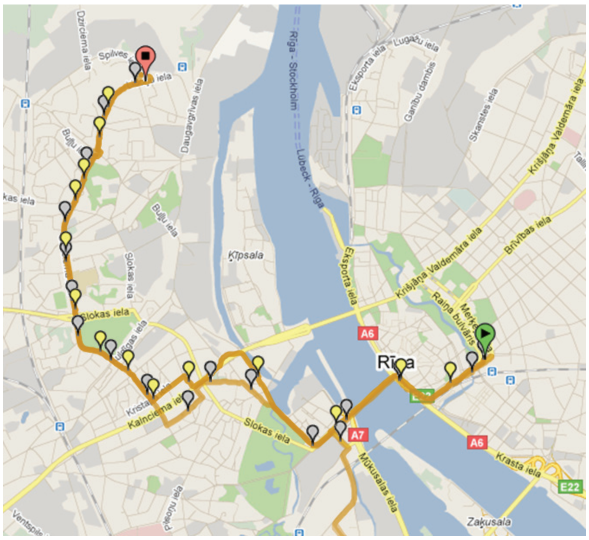

Fig. 4. Example of existing stops fragment for tram No 4 Source: [9]

t – the time, t1, t2, .. ti – moments of time;

$P^{tr}=\{ P^{tr}_1, P^{tr}_2, ..., P^{tr}_n\}$ the set of tram stops n=1,2, ...;

$P^t=\{ P^t_1, P^t_2, ..., P^t_u\}$ the set of trolleybus stops u=1,2, ...;

D – the distance (roots); d – nodes/stops of transport network $d_1; d_2; .... d_m \in D$

Z^o_p – priorities of passengers;

W – the environment;

W_v – the influence of environment;

$W^{(I)}$ – feedback (transport control system);

W_x – the input of the transport system (resources, passengers);

W_y – the output of the transport system (resources, passengers);

A^s – the set of intelligent agents (intelligent agent network) with subsets $A^{st}_1, A^{st}_2, ..., A^{st}_m, A^{sp}_1, A^{sp}_2, ..., A^{sp}_m, .. \in A^s$; m=1,2, ...,

A^{supra} – Supra intelligent agent;

Dp – distributed data bases;

Wd – distributed Web server (servers);

$\exists\ S^t_n \in S^p_k\ S^{te}_j\ (S^t_n, S^p_k)$ -> min, (exists when S^t_n, as for each S^p - $S^{te}_j\ (S^t_n, S^p_k)$ exists;

Target function S^{te}_j -> min, $S^t_n \in S^t_{direkt}$.

For the areas around railway nodes or nodes of hyper graph the principle [11] shown in Fig. 3 is applied.

8. Numerical example for the calculation of sufficient number of services

There is a wide range of statistical data from e-tickets: personalised e-tickets, non-personalised e-tickets, and smart-tickets with necessary products.

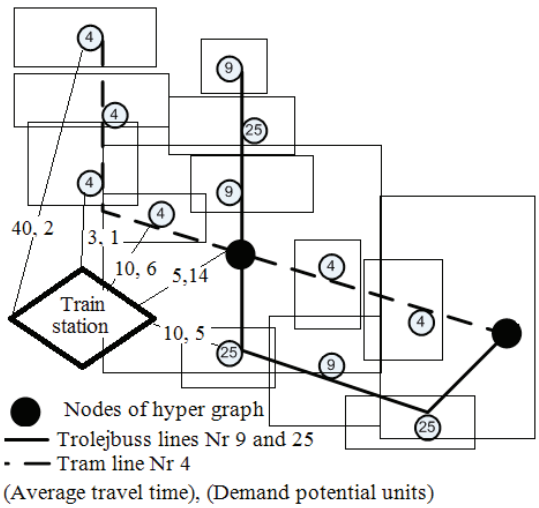

Fig. 5. The analysis of average travel time and demand potential units

The integration of railway transport in the Riga city public transport control is important for passenger's service, using the existing recourses. However, the integration of transport control systems has just started, being developed for 3 years. A bus control system – ASOS – was the first implemented system. The use of a transport control procedure for co–modal transportation of passengers in the city of Riga is very important. An example of telematic tools application for the city of Riga is well-described in [8]. The dynamic control of transport modes in a pre-defined time interval and a composite final control procedure for each transport mode and the traffic harmonisation aimed at transport arriving on time and the harmonisation of railway and public transport traffic, maximally using the existing infrastructure capacities by defining transit flows in transport nodes (hyper graph nodes). An effective tool of research for problems of optimum control is the principle of a maximum by Pontryagin's Maximum Principle representing a necessary condition of optimality in such problems. The procedure consists of two main parts: an operating procedure, in this case the routing of passenger's flow, and the object of control, in this case the passenger transport. The objects of control divided into three levels, means of transport, a vehicle, or all the system of city public transport etc., can be considered. The operating kernel since the occurrence of control problems has undergone evolutions from an elementary regulator to modern information systems – intelligent transports system.

Validation of the existing origin-destination. The current transportation surveys depend on sample surveys – vehicle number plate survey, roadside interview survey, site visiting survey, cordon line survey. However, the smart card data has complete survey data for all the travel. In addition, it's very easy to obtain some special data, such as in-vehicle persons.

Transit service system establishment. The current demand forecasting is based on historical data more than a year ago. However, the smart card data is up-to-date data acquired at least a month ago. The data is not forecasted data but the actual data. Using the smart card data, the transit demand can be analyzed and the schedule can be optimized.

Transportation policy before-and-after assessment. Researchers may develop the transit assignment and schedule optimization models with the smart card data. These models may be utilized to pre-assess projects, such as new railroad construction. The smart card data includes these items irrespective of the region and operator. Each smart card has a unique ID and a passenger's travel information can be detected as a set of stops and stations. With these sets of stops and stations, passengers' also travel routes can be calculated. Depending on the smart card type, some of them include the privacy protection. According to the privacy agreement, the private information is excluded from this research [12].

Transaction ID is to form a trip chain by linking each trip segment of various modes and lines. Transaction ID enables to generate trip chains from each trip segment. For example, it's available that "One passenger takes line N of mode B from origin A, and transfers to hyper graph node at the place of A, and arrive at the place of C." The origin and the destination correspond to stops or stations that passengers visited, so one can get precise origin-destination data compared to the existing transportation planning. Stops or stations are approximate passenger's actual (real) origin-destination, in the catchment area. However, the data used had the limitation that did not record each trip, but only from personalized e-talons.

In the Riga area, the public transport fare is constant and does not depend on the travel distance, but in the future it can be adjusted to the travel distance. To measure the distance on a vehicle, passengers bring their cards close to the card reader on the vehicle (or station) at their getting on and off. This means the limitation described previously can be solved. The travel distance data is available in the smart card system.

9. Real database building

The key point of Real DB database is to build the entire passenger trip chain data from segment smart card data. Real DB database can be built from all segments of bus, trolleybus, tram trips, so a Real DB database user is able to analyze the transit DB and route. The raw data processing to build a Real DB database follows these principles [12]:

- make sets of segment data by the same smart card ID and Transaction ID,
- sort the transfer order within the same transaction,
- generate a unit of Real DB data as shown in Figure 5,
- build a database of Real DB data.

Table2. Smart card data items [12]

Data Items	Items details
Smart card ID	Each smart card's ID (passenger ID)
Departure date and time	Departure time of a current vehicle (train)
Transaction ID	Each passenger's travel ID
Mode code	Current mode's ID
Number of transfers	Number of transfers is a trip chain
Line ID	Current line's ID (line number)
Operator ID	Company operator ID
Vehicle ID	Current boarding vehicle's ID
Passenger class	Passenger class ID (general, student, aged, handicapped etc.)
Boarding time	Boarding or transfer time (sec. units)
Boarding stop ID	Stop (or station)'s ID of boarding or transfer
Alighting time	Alighting time (sec. units)
Alighting stop ID	Alighting stop (or station)'s ID
Alighting fare	Additional fare charged proportionally to total distance
Date and time	Travel date and time

The summed data is calculated by the sum of each segment smart card attribute value. The sum of time used for transfer can be calculated by the sum of time gaps between the time of alighting and the next boarding time acc. to the time order.

A unit of Real DB data [12]:

- Smart card ID;
- Boarding stop (or station) ID where the transfer order is 0 (the first boarding);
- Alighting stop (or station) ID when the transfer order is maximum (the last boarding);
- The number of passengers that own the card (generally 1);
- The sum of each trip segment distance within the same transaction ID;
- The sum of each trip segment time within the same transaction ID;
- The sum of each trip segment fare within the same transaction ID;
- The number of transfers;
- The sum of each time used for transfer (within a trip chain).

The trip chain data is very helpful to analyze the transit information and to estimate the demand. A spatial analysis and transit project assessment can be performed with geographical data and tools. With the Real DB database, the transit assignment models can be developed. In addition, the schedules optimized to the real demand are also derived. Further algorithm research, however, is needed. Especially, the Real DB data is a kind of actual data, not estimated data. It's very powerful to calibrate coefficients of each model's demand estimation, transit assignment, and schedule optimization [12].

The planned timetable with a driving record and the rate of delay can be calculated. The mode share can be derived by a mode's total passenger-km divided by all mode's total passenger-km within the time slot and the DB. In the DB analysis, the basic analysis of the above figure, as well as valid routes of certain DB, an average transfer time by the route, a comparison with the road network path, a railroad share by the route, a passenger assignment rate by the route, are available in Real DB.

Generally, each index might be analyzed by the time slot, the region, the passenger class, and the mode. The data integration analysis is also available for the indices. Besides, the research on the data integration of transit data and highway traffic data is needed.

The passenger class is divided into general, student, disabled person, the aged matching to the smart card classification. It is aimed at analysing the trip/travel pattern by the passenger class and at suggesting appropriate service strategies for each class. [12].

Table 3. Transportation indices derived from the smart card data [13]

Class	Index	Calculation
Transportation elements	Passengers by the stop (station)	Boarding and alighting passengers by the stop (station)
	Passengers by the mode and the line	Boarding and alighting passengers by the mode and the line
	Passengers by the passenger class	Boarding and alighting passengers by the passenger class
	Avg. passenger per vehicle	Total boarding passengers per total vehicles
	Avg. passengers in a vehicle by the vehicle	Sum of in-vehicle passengers in the section, divided by the number of sections
	Avg. travel time per passenger	Avg. gap between the boarding time and alighting time
	Avg. distance per passenger	Avg. route distance between the boarding stop and alighting stop
	Avg. number of trips per passenger	Total number of trips divided by total passengers
	Avg. travel time by the mode	Sum of all passengers' travel time divided by the number of passengers * Calculate for each mode
	Congestion in a vehicle	Current in-vehicle passengers + boarding passengers – alighting passengers
Fare	Avg. fare per passenger	Total fare charged divided by total passengers
	Total income by vehicle	Total fare of a vehicle's passengers
	Total income by line	Total fare of a line's passengers
Transfer	Avg. number of transfers	The number of all trips divided by total passengers
	Avg. transfer time	Transfer time: the time gap of previous alighting and current boarding
	Avg. transfer cost	Transfer cost: additional fare for transfer
Volume (Passengers)	Passenger by the OD pair	Sum of all passengers through all modes from one stop(origin) to another stop(destination)

10. Environmentally sustainable transport

The environmentally sustainable transport can be defined in two ways:

- as the application of environmental sustainability to the transport sector or to elements of this sector
- as the environmental pillar of sustainable transport, which makes the definition of the concept of sustainable transport necessary.

There is no generally accepted definition of the term "sustainable transport" (like its synonyms 'sustainable transportation', 'sustainable travel' and 'sustainable mobility'). The expression is often used in order to describe all forms of transport which minimise the environmental impacts, such as the public transport, car sharing, walking and cycling, as well as technologies such as electric and hybrid vehicles and biofuels.

While the conceptualisation of the sustainable transport using the 'three E's' of environment, equity, and economy is widely accepted according to [14,15], the problem with this

Table 4. Trusted Service Criteria

Standard role	Typical criteria row *	Comments
Driving on the schedule **	At least 80% arrive in time (delay 0-5 minutes) – at the peak time, usually 90% accuracy	Short intervals
Boarding and disembarking time	Max 3 - 8 minutes stay at the station	Used for small transport enterprises
Immersed journeys **	A minimum of 90% - 95% on schedule	Immersed journeys is at risk of reliable service criteria
Passenger safety **	Maximum of 6-10 passengers to 106 passengers in an emergency. Max 4-8 crash to 1.6 * 105 vehicle-km	Dependent on updated data about security
Passenger complaints	There is no restriction, on the complaints driver / time	Passenger complaints always be received

*** Displays the main data from the U.S.**

**** Typically used standards**

approach is that it has the potential to perpetuate the status quo by only focusing on a change within the transport sector to the exclusion of change across sectors. Transport is only one sector and it must work in conjunction with other sectors or areas – such as energy, manufacturing, and housing / land use – if system transformations are to be made towards sustainable development [15]. In other words, a sector such as transport or agriculture cannot be characterised as sustainable or unsustainable, because they are not independent of the other sectors. However, transport can be characterised either to contribute or not to contribute to the sustainability of society, all other things being equal. Biofuels are a good illustration of this. From a transport point of view, biofuels are or could be sustainable (considering only transport energy), because they could be a renewable source of energy. But if the production of biofuels is made to the detriment of the diet of a large part of the world population, biofuels cannot be described as sustainable [4].

Currently, the air quality in the city of Riga is poor, so it is the time to seriously think about reducing the number of vehicles in the city centre. Currently, the company "Rigas Satiksme" opens up a number of new paid car parks in the city. The aim is to optimize the traffic in the city, especially on streets with heavy traffic of public transport. It is important to streamline the flow of cars and to arrange the parking so that motorists can drive up close to objects of interest to them.

Reliable service attributes that apply to passengers:
- Waiting time;
- Boarding time;
- The opportunity to sit in the vehicle;
- Travel time;
- Disembarking;
- The total running time (including embarkation and disembarkation);
- Data transmission time;
- Advance information on driving times.

Reliable service attributes relating to the administration:
- Departure according to a list;
- Route keeping the schedule;
- Space allocation;
- Individual vehicle space;
- Departure time;
- Missed routes;
- Technical emergency;
- Message on retention time;
- Driver's driving experience.

Externally, reliable service attributes:
- Road congestion;
- Accidents on the streets;
- Incidents
- Weather.

11. Conclusion

The task of development of electric power application, an effective improvement in the public transport system is formed as a formal task of model investigation that can provide the affectivity of the exiting transport system investigation that is significant for economy especially under the conditions of hard city traffic. The task of the power consumption optimization is connected with technologies and methodology that can provide passenger's transportations with more effective application of the available resources and avoiding duplicated routes to provide effective use of electric energy. The graph theory is applied to develop power consumption affectivity improvement.

The existence of difficult dynamic topologies; the priority of the customers and its changing with time; not enough statistical data for the modelling were taking in to account.

The procedure of improvement to the quality of service, time, costs, electric energy effective use. The concept of hyper graph is used with a combination of aid – a base graph approach in numerical calculations was used. The role of aid – base graph approach is numerically examined. The suggested theory is assessed with the use of a homomorphic model.

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