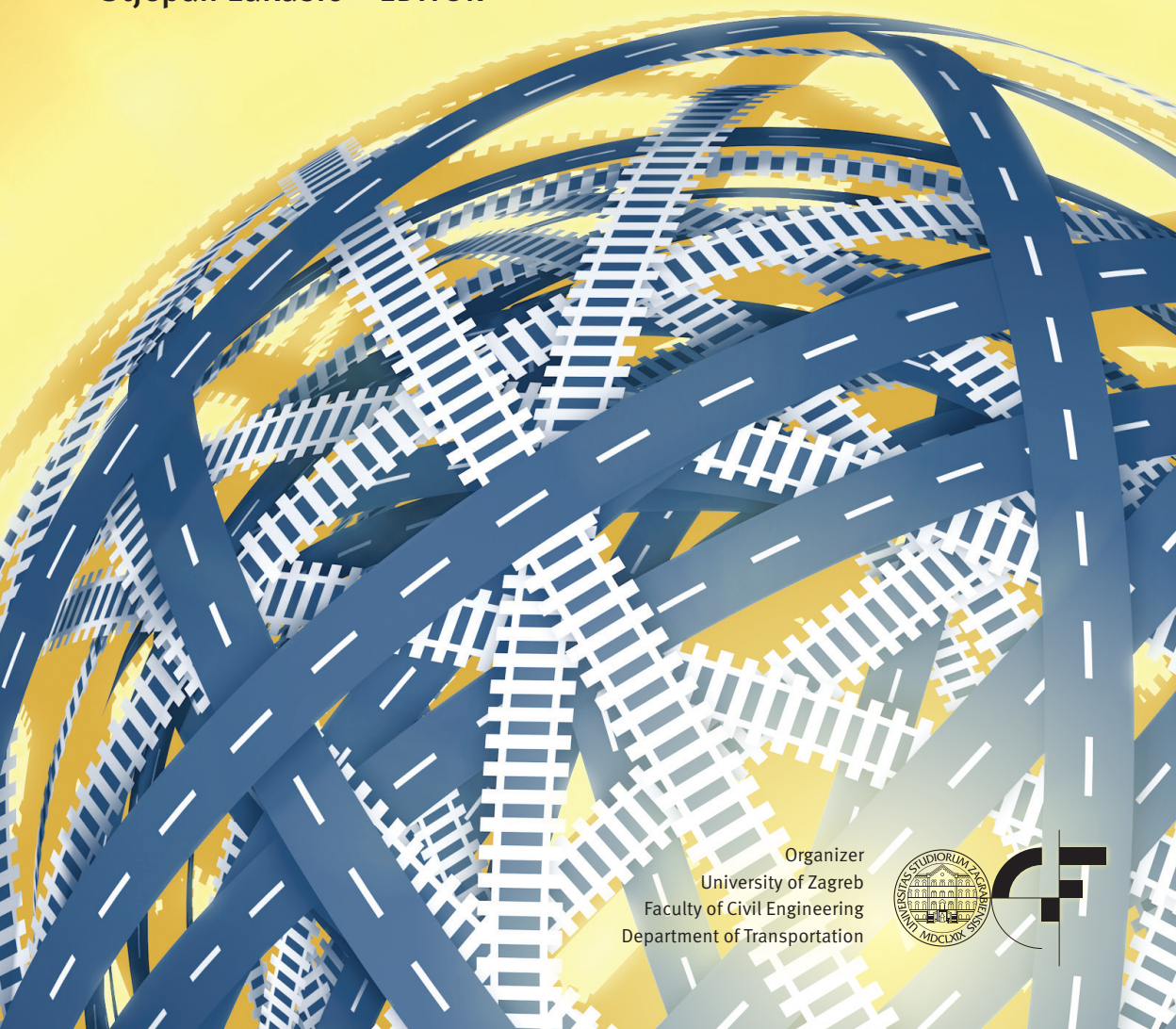
CETRA 2016

4th International Conference on Road and Rail Infrastructure
23-25 May 2016, Šibenik, Croatia

Road and Rail Infrastructure IV

Stjepan Lakušić – EDITOR



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ESTABLISHING THE CAPACITIES IN THE INNER CITY – SUBURBAN RAIL PASSENGER TRANSPORT

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Abstract

Required capacities are determined by the number of transported passengers, however, current practice of counting passenger by number of tickets sold or by manually counting the passenger in a given time period is neither reliable nor accurate. Use of IT technology is necessary for reliable and accurate counting of passengers. During the study of transport demand, the following component which are important for the analysis have been identified: a) number of transported passengers, b) utilization of the travel route and c) capacity utilization. Such research of demand for transport can be used for inner city-suburban and regional transport in order to precisely establish the share of subsidies which can be obtained by each of the transport modes, which can have a significant impact on the price of the ticket.

Keywords: inner city, travel route, passengers, capacities, suburban rail

1 Introduction

Total demand for transport capacities (Figure 1) depends on the quality of provided service. Demands of the transport users define the concept and development of transport. Total demand may be viewed by sectors (air, water and land transport) and through areas of demand as per the regions in which such transportation takes place. Land transport can be classified by the means of transport being used (road or rail transport) and it is defined by the route on which it takes place. Land transports can be domestic, on routes within a country or international, if it takes place between at least two countries.
Division of transport serves to provide transport users – passengers a quality service of access, use and choice for means of travelling. In order to take into account the demands of an individual group of rail transport users, we can categorise the trains in three transport categories [1]:
- (GPP) Inner city and suburban transport (ICST)
- (RP) Regional transport (RT)
- (DP) Long-distance transport (LDT)

Inner city – suburban transport, as mass transit, takes place in one gravitating region in daily migrations which is dependent on:
- Level of concentration of employment or education locations
- Level of concentration of places of residence
- Travel distance coefficient
- Coefficient for transferring from one means of transport to another
- Transport capacity utilization coefficient

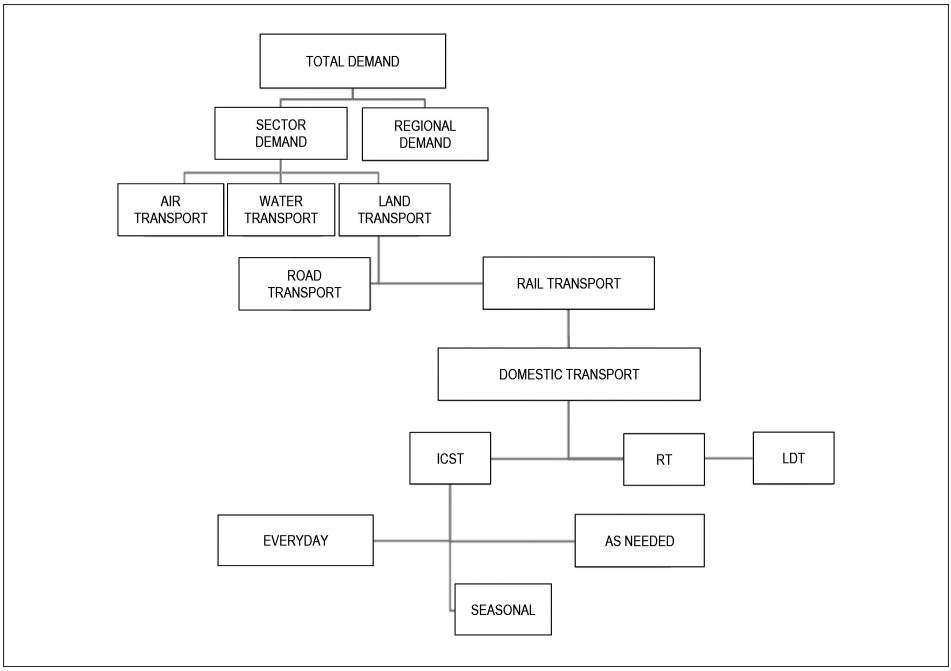

Figure 1 Concept demand model

2 Structure of transported passengers in the Republic of Croatia in the transport subsystems

According to the data of the Croatian Bureau of Statistics in 2013 share of passengers transported by rail in the total number of transported passengers was 28.8% (Figure 2). When one passenger uses several modes of transport from specific transport branches, such passenger is counted as one passenger in each one of them.

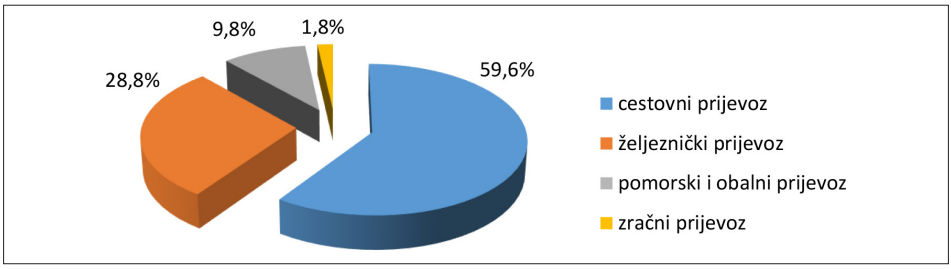

Figure 2 Structure of passenger transport according to transport types, January – June 2013. (Source: Croatian Bureau of Statistics)

In order to establish whether the percentage of increase or decrease of the gross domestic products has any influence on the travelling habits of the population, it was compared to the data of the HŽ putnički prijevoz on the number of transported passengers in the period from 2010 to 2015 [2]. For comparison, the data on the number of unemployed in the same time period was obtained from the Croatian Bureau of Statistics.

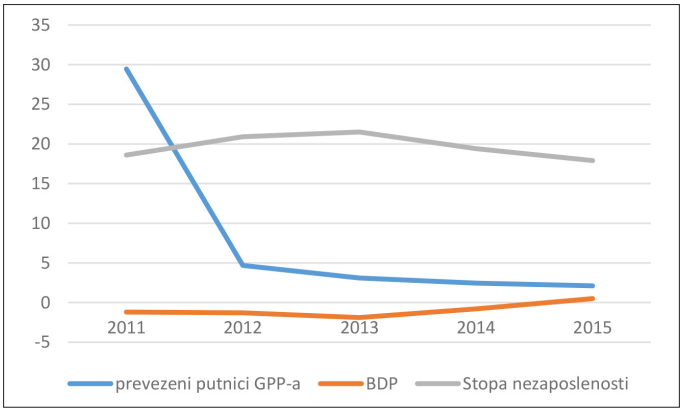

Figure 3 Comparison of the GDP trend, number of transported passengers and unemployment rate trend (Source www.dzs.hr, HŽPP)

According to the data of the Croatian Bureau of Statistics [3] the value of the gross national product in the Republic of Croatia (Figure 4) viewed for the period 2010 – 2012 stagnated. In the period 2012 – 2013 the gross domestic product increased, and it slightly decreased in the period 2013 – 2015. A conclusion was made based on the comparison of the percentage of increase or decrease of the GDP, number of transported passengers and the unemployment rate (/prevezeni putnici GPP-a – transported passengers in the inner city-suburban transport area; BDP – GDP; stopa nezaposlenosti – unemployment rate/Figure 3), according to the data of the Croatian Bureau of Statistics and HŽ putnički prijevoz. Number of transported passengers i.e. number of sold tickets is not correlated to the GDP and the number of unemployed persons. Number of tickets sold suffered a steep drop in the period from 2010 to 2012 when there were no subsidized HŽ – ZET joint prepaid tickets.

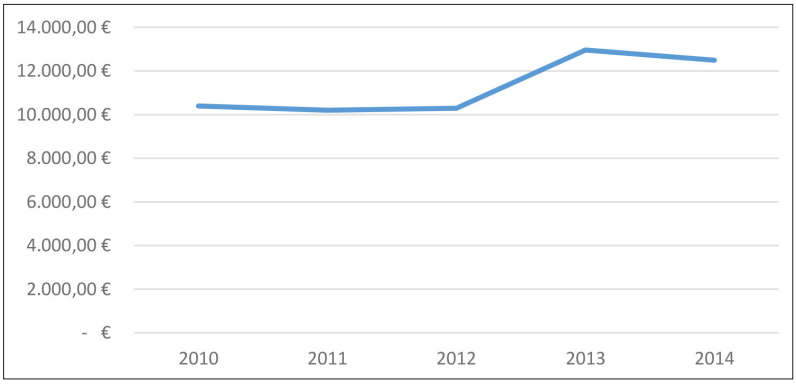

Figure 4 Gross National Product (Source www.dzs.hr)

3 Train capacity utilization

Analytical model for establishing the number of passengers travelling with HŽ putnički prijevoz, which is based on counting the number of passengers at the official locations when the passengers are boarding or leaving the train in a certain time period does not provide reliable information. Income generated through the sale of tickets does not follow the trend of the number of transported passengers (Figure 5).

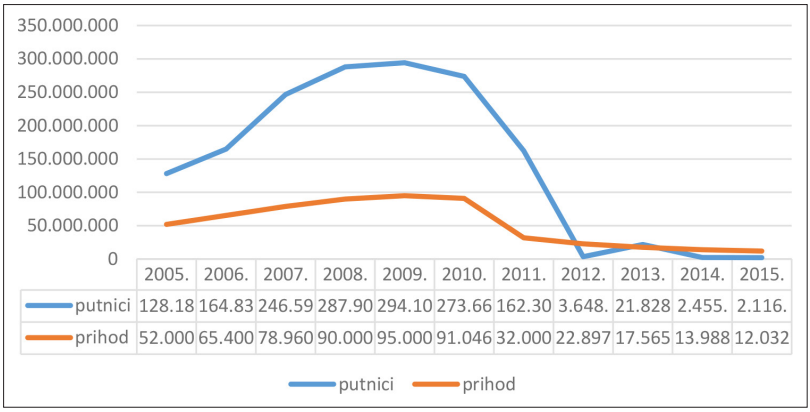

Figure 5 Chart of the number of transported passengers trend (Source: HŽPP)

Determining necessary capacities depends on the parameters which are dependent on the times of day, day in a week and a direction of travel. Therefore, in order to establish capacity the following parameters are needed:

- Number of trains during the peak load hours
- Number of trains during other times of day
- Train occupancy
- Route utilization
- Number of undefined passengers

Train occupancy coefficient varies with the time of the day. By dividing it into several time intervals we can calculate the average daily capacity of passenger train's occupancy. The calculation is based on each reference point on the route which we can define as an official location on the observed route with the regard to the passenger flows.
Considering the standing classification of trains in which they are not defined according to transport sector (inner city-suburban; regional transports), it is not possible to determine how many passengers from the inner city – suburban transport uses regional transport trains. Sesvete train station was set as an official calculation point, and six daily time periods and a total of 65 trains which perform actions at the train stations and stops so that the passenger can get on and off of trains (Table 1).

Table 1 Daily intervals of the occupancy coefficient

	Occupancy coefficient (%)	Time period	Number of trains
K1	0,05	4:30 – 6:00	7
K2	0,8	6:00 – 8:30	13
K3	0,1	8:30 – 13:00	12
K4	0,6	13:00 – 16:30	13
K5	0,1	16:30 – 21:00	13
K6	0,05	21:00 – 0:05	7
Source: chart 1a, timetable 2014/15, HŽI			

Based on the aforementioned time periods with different occupancy coefficients, and under the assumption that undefined passengers only appear in significant numbers during peak hours (Knp2=0,1% and Knp4=0,05%), an average occupancy of the train at the daily level for one direction of travel can be calculated by using the following equation:

$$N_p = n_{kap} \cdot [n_{v1} \cdot K_1 + n_{v2} \cdot (K_2 + K_{np2}) + n_{v3} \cdot K_3 + n_{v4} \cdot (K_4 + K_{np4}) + n_{v5} \cdot K_5 + n_{v6} \cdot K_6]$$ [passengers/day]

Where:

n_{kap} – Capacity of the means of transport
n_{v1-6} – Number of trains in a certain time period
K_{1-6} – Train capacity occupancy coefficient
$K_{np2\ i\ 4}$ – Undefined passengers coefficient

Therefore:

$N_p = 432 \cdot [7 \cdot 0,05 + 13 \cdot (0,8 + 0,1) + 12 \cdot 0,1 + 13 \cdot (0,6 + 0,05) + 13 \cdot 0,1 + 7 \cdot 0,05]$
$= 10.087,2$ [passengers/day]

In the year 2015, with 298 work days, at the subject location, according to average capacity usage, 3,005,958.6 passengers were transported in 18,775 trains with a maximum capacity of 8,110,368 passengers, which means that the average annual occupancy percentage on the work day was 37.07%. Taking into consideration that the sale of monthly tickets does not give any information on how many days the passengers use the tickets for riding the train and that these are high-school student/student and worker prepaid tickets, we made the following assumptions:

- Monthly high school student/student prepaid tickets used on the day from Mo – Fr.
- Monthly prepaid worker tickets are used on the day Mo – Sat.
- Return and RVC tickets are used on all days

According to these assumptions for the time period in which a reduced number of trains operates, for the remaining days the average daily occupancy coefficients reduces drastically and it is within 0.10 – 0.25 range. According to the data of the HŽ putnički prijevoz, out of 218,356 tickets sold at the official locations (Table 2) According to the data of the HŽ putnički prijevoz, out of 218,356 tickets sold at the official locations.

Table 2 Number of dispacthed passengers per official locations for the period 01.08. – 31.12.2015:

Official location	Number of tickets sold per travelling route						
	Dugo Selo	Sesvetski K.	Sesvete	Čulinec	Trnava	Maksimir	Zagreb GK
Dugo Selo		875	9.623	2.691	3.066	9.684	42.829
Sesvetski K.	441		687	109	194	569	5.931
Sesvete	7.021	830		109	1.199	3.201	39.121
Čulinec	1.273	195	491		6	351	7.939
Trnava	934	281	921	2		156	7.191
Maksimir	2.144	261	1.226	159	107		2.235
Zagreb GK	23.839	6.752	23.360	4.627	4.302	1.100	
Source: HŽPP							

According to the above table, necessary capacities for the route sequence of official locations can be determined and according to this we are able to determine the relevant point for measuring the necessary capacities. Manner of tracking the passenger numbers by sold train tickets determines the route utilisation coefficient (Figure 6).
In the integrated passenger transport the aforementioned analysis can serve as the basis for optimisation of infrastructure capacities for receiving and dispatching passengers and capacities for other modes of transportation with which the passengers continue their travel, regardless whether this is personal transport or public city transport.

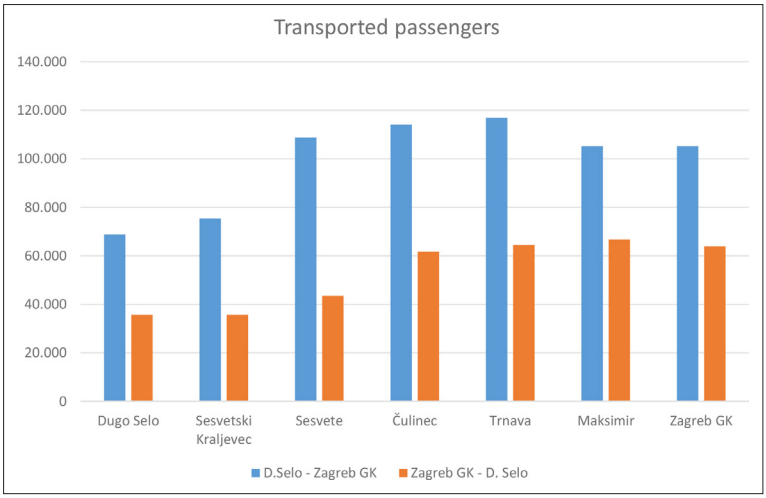

Figure 6 Necessary capacities through the route sequence of the official locations

4 Spatial, temporal, quantity and structural optimization of transport capacities

Optimization of transport capacities pertains to:
- Spatial optimization – separation of access infrastructure structures from other public areas by enclosing and grade separation.
- Temporal optimizations – introduction of regular interval timetable according to maximum throughput of a track section.
- Quantitative optimization – optimal number of powered trains for necessary demand capacities
- Structural optimization – defining the boundaries of transport regions by travel time distance.

Spatial optimization of capacities pertains to the physical means of separating platform areas from other public areas by barriers (fences, track grade separation and official locations – stops and elevated access ramps), dislocation of official locations – stops and elevated access ramps), dislocation of official locations – stops, building second track at single-track rails and determining the start-end train stations based on the travel time intervals (Figure 7). Physical separation of platform areas from public areas also allows for installation of passenger counting devices and the examples which can be followed for separation of the platforms from other public areas can be seen at the Čulinec and Maksimir stops where passenger access to the island platform is realised by underpasses so there is no crossing between the movement of pedestrians and trains.
Standardized platforms and hoods are placed at every renovation not only within the area of inner city – suburban transport, but in all official locations for receiving and dispatching of passengers. According to the existing accepted standards, minimal width of the island platforms without underpasses is 6000mm, whereas the width of the platforms with constructed underpasses/overpasses is 9500mm. [4].
Major overhaul of the Dugo Selo – Zagreb Borongaj track does not include the station areas of the Sesvete station and the access to platform areas and to the platforms themselves is arranged as maximum possible usable area between the tracks.

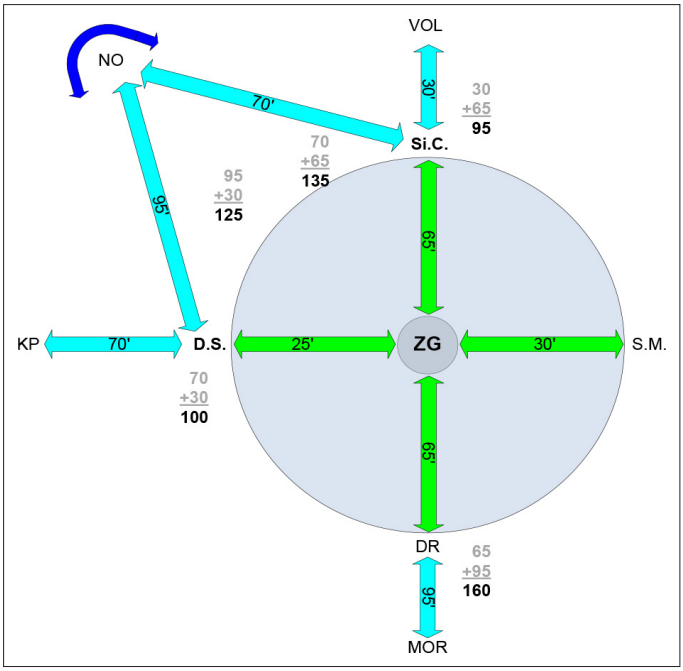

Figure 7 Establishing transport boundaries based on the temporal component

Height of the arranged surfaces for entry and exit of passengers at the Sesvete and Dugo Selo stations are unacceptable due to them being unfit and impractical. The surfaces are located within the passenger safety zone and they are 1000 – 1200mm wide, and the height of the platform is 200 – 350mm. This was recognized as a problem as early as during the nineties of the last century [5].

By looking at the example of spatial placement of the Maksimir stop and Borongaj train terminals, we can see that there is a problem regarding passenger transfer from one mode of transport to another. In such cases, existing railway stops need to be moved to the immediate vicinity of other transport structures in order to facilitate access and transfer from one means of transport to another for passengers.

Temporal optimization of transport capacities denotes the temporal component by introducing regular interval timetable. By specifying the regular interval also determines the transport capacities during the day time intervals with regard to capacity requirements. In the Municipal Passenger Transport of the City of Zagreb a regular interval timetable of 10 minutes was proposed, which would enable maximum transport capacities in peak load hours (Figure 8).

Quantitative optimization means the renewal of transport capacities in quantities necessary for meeting the needs. Due the lack of funding, optimization had to be divided into stages. Desired final results of each of the specific stages determine how successful the realization was [6]. Structural optimization of transport capacities defines the division of passenger transport depending on the travel time distance and defines the boundaries of inner city-suburban transport, regional transport and long-distance transport. In the inner city-suburban transport areas, trains used inner city-suburban transport would have priority with regard to all other trains, and for passengers it would be made easier to get around and choose trains by certain visual identity of every train group.

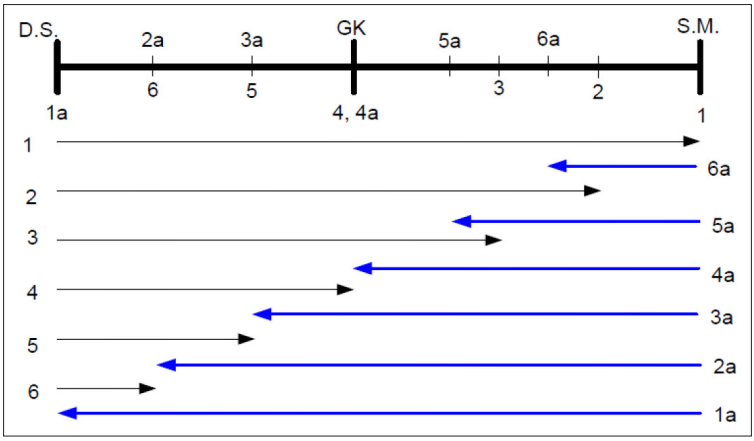

Figure 8 Position of each of the trains in the inner city – suburban transport in time t=55'

5 Conclusion

In the passenger transport, the passenger participates in the process of service production i.e. the result and processes of production are indivisible. This means that each passenger carrier must ensure constancy of service, since every disturbance in the providing of such surface would have an effect on the passenger satisfaction. In order for the passenger carrier to, to meet passenger demands, the passenger carrier must constantly improve the quality of his service. The passenger is a transport object which has its own personality and certain requirements and the passengers demand safety, speed, comfort, tidiness and appropriate price for transport services. Therefore, the carrier must meet the high demands of the passengers and offer them appropriate level of service. Quality service increases passenger satisfaction and ensures passenger loyalty. For that purpose, the carrier must ensure availability of service and work on improving such service in order to remain competitive in the liberalized market. By tracking and analysing the everyday movements of passenger flows, and capacity utilization of an individual train the carrier is able to respond to passenger demands and improve the quality of provided services by changing the requirements in the amendments to the train timetable in effect which are done every two months. By drafting transport studies for urban environments, we seek an answer to the demand for public transportation in order to make a positive effect on the quality of life.

Area of the micro-location of the City of Zagreb in the inner city-suburban transport is the route of that type of transport under the greatest load, with largest number of passengers during the year. Considering the gravitation area, throughput of the track, constructed infrastructure, state of infrastructure subsystems, quality of traction and transport means and supply and demand of transport services, the study and obtained results are applicable to other parts of the network in which the inner city-suburban transport is organised. In order for the carrier to keep up with the passengers' demands, the work methodology needs to be adapted:

- by establishing zones of operation – taking into consideration time component of the distance and by setting the traffic rules and introducing a single transport identification, the quality of transport services is improved. Gains obtained by doing business in this way are an affordable ticket price, regularity and reliability
- by defining operating boundaries – by setting traffic rules and regulations, tariff harmonization and division of financial shares in the transport, it is possible to influence the amount of subsidies provided by the city, local communities or state in the inner city-suburban transport, which has an effect on the price of the transport card for end-user.

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