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THE INFLUENCE OF THE INTRODUCTION OF PUBLIC TRANSPORTATION LANES IN THE MUNICIPALITY OF BUCHAREST

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Rezumat

Municipiul București împreuna cu județul Ilfov formează o aglomerarea urbana cu peste 2,2 milioane de locuitori. In prezent datorita depășirii capacitații de circulație a șoselei de centura a capitalei, singura posibilitate de călătorie Nord – Sud sau Est- Vest este prin centru orașului. Rețeaua de transport public din municipiul București suferă din cauza absentei unor benzi de rulare dedicate transportului in comun, lipsa unei rețele extinse de semaforizări adaptive si a unei semaforizări care sa ofere prioritate mijloacelor de transport in comun. De asemenea gradul mare de încărcare cu vehicule al rețelei stradale conduce la un nivel de serviciu scăzut atât in ora de vârf de dimineața cat si in cea de după amiaza, ducând la viteze de transport scăzute ale mijloacelor de transport in comun de suprafața. In cadrul acestui articol sunt identificate posibilitățile introducerii benzilor dedicate de transport public in municipiul București, cuantificându-se reducerea timpilor de călătorie. In plus sunt prezentate câteva soluții tehnice privind infrastructura necesara introducerii benzilor dedicate vehiculelor de transport in comun si posibile masuri de reglementare a circulației.

Cuvinte cheie: trafic, transport in comun, nivel de serviciu, timpi de călătorie

Abstract

The city of Bucharest together with Ilfov county form an urban agglomeration with over 2.2 million inhabitants. Currently, due to exceeding the traffic capacity of the capital's ring road, the only possibility to travel North - South or East - West is through the city centre. The public transport network in the city of Bucharest lacks lanes dedicated to public transport, the lack of an extensive network of adaptive traffic lights and traffic lights that give priority to public transport. Also, the high degree of vehicle loading of the street network leads to a low level of service both in the morning peak hour and in the afternoon rush hour, leading to low transport speeds of surface public transport. In this article, the possibilities of introducing dedicated public transport lanes in the city of Bucharest are identified, quantifying the reduction in travel times. In addition, some technical solutions regarding the necessary infrastructure for the

introduction of lanes dedicated to public transport vehicles and possible traffic regulation measures are presented.

Keywords: artificial neural networks, traffic, service level, vehicle queues

1. INTRODUCTION

1.1. General context

Bucharest is the capital of Romania and the largest city in the country, with an area of 228 km2 and a population of over 2.2 million inhabitants. The city and the metropolitan area (with an area of approx. 365 km2) are undergoing a considerable change and economic development with the accession of Romania to the European Union in January 2007. At the same time, this metropolis represents an important node of the transport infrastructure, through the links that offers them on the three highways (A1, A2, and A3), with national and county roads.

Another peculiarity of the city of Bucharest consists in the street network which is of radial type, with a slightly irregular and non-uniform urban fabric [1]. The connection between the residential areas and the central area is made by means of major arteries, built in a large majority before 1989. Currently, due to exceeding the traffic capacity on the ring road and the intersections between it and the penetrating arteries of the capital, the only possibility of travel in the directions North - South or East - West is through the city centre.

Another problem of the capital is the imbalance of the built surfaces within the urban cells. This led to an increase in the density of jobs or the appearance of new residential developments, which generated additional pressure on the current transport infrastructure. An eloquent example consists of "home - service" trips from bedroom neighbourhoods to office areas located mainly in the northern area of Bucharest. In addition, the process of approving some collective housing in the existing neighbourhoods, from which we can list the areas of Dorobanti, Damaroia or Bucuresti Noi have generated an additional demand for transport amplified by the use of cars for most trips.

In order to improve traffic conditions, in recent years the municipality has focused on completing the central ring road or on the construction of road under or overpasses in the area of Casa Presei Libere, Baneasa, Pipera road or the connection between the A3 highway and Petricani road. These projects reduced the travel times on some of the penetration arteries in Bucharest, but they additionally requested the street tram in the central area.

In the City of Bucharest, the public transport system (managed by the Public Transport Company - STB) consists of 76 bus lines, 17 trolleybus lines, 24 tram lines and 5 metro lines, using a fleet of 1977 vehicles (of which 83 are subway cars) [3].

At the moment, the lanes dedicated to public transport are those on Kogalniceanu boulevard in the Opera - University direction, partially on Splaiul Unirii and Strada Decebal or those for the tram lines on Calea Vacaresti, Șoseaua Mihai Bravu, Șoseaua Stefan cel Mare and ȘoseauaColentina. The high degree of vehicle loading of the street network leads to a low level of service both in the morning and in the afternoon rush hour, leading to low transport speeds of the surface public transport.

1.2. Existing situation

Characteristic for the City of Bucharest is the accelerated increase in the number of vehicles determined by the economic growth of the capital. Traffic conditions have worsened in recent years, which is reflected in the increase in the number of registered vehicles. In fact, traffic volumes in the central area vary between 30,000 vehicles/day and 50,000 vehicles/day. In winter, the congestion becomes even greater due to the slippery surface and the accumulated snow on the edge of the roadways, reducing the width of the traffic lanes.

Currently, Bucharest City Hall, by approving the Sustainable Urban Mobility Plan 2016-2030 - Bucharest - Ilfov Region, has assumed an integrated transport policy. An important chapter of the transport policy consists in encouraging some forms of transport, which will reduce traffic jams and reduce pollution. An important element in this strategy is the development of public transport.

A possible solution to reduce traffic congestion in Bucharest is to encourage the use of public transport and discourage private vehicle traffic. One of the main disadvantages of public transport is the low manoeuvrability, because they are conditioned by the existence of fixed routes. The frequent modification of the routes is difficult to achieve, causing confusion on the journeys. If there is enough space for the segregation of public transport routes, in relation to other vehicles, as was done in the cities of Ipswich and Leeds in Great Britain, public transport vehicles have the possibility to bypass congested areas. Usually, however, city planning does not allow this, except at very high costs.



Figure 1. Segregated carriageway for buses in the city of Leeds in Great Britain

1.3. Traffic model

In this article, a macroscopic analysis of the current situation of public transport was carried out by using the Bucharest transport model for the annual daily average (ADA) which required a local calibration.

Thus, in order to update the transport request for the base year 2021, the following activities were performed:

 Detailing the street network and zoning (of the connectors in the present case) in the central area and on the main public transport routes.

 Recalibration of the origin-destination (O.D.) matrices for the base year using the traffic data recorded for one week (period 14/05/2020 – 21/05/2020) for the morning peak hour (A.M.) and the peak hour of in the afternoon (P.M.) [4].

Within this transport model, the following can be simulated:

• generation of traffic demand for each area considered (territorial unit),

• the distribution of trips between the areas considered, which are:

- 80 zones for the administrative area of Bucharest,
- 40 zones for the localities of Ilfov county and Otopeni airport
- 60 external areas representing counties in Romania

• distribution between modes of transport: private, public and between modes of public transport;

• the impact on the network for private transport and public transport;

 The public transport network is represented by the surface and metro public transport lines, with related services.

The transport model for the base year is calibrated based on the relationship between the characteristics of the transport system, demand and socio-economic parameters. The socio-economic factors considered as determinants in the

generation of traffic are: the population, the jobs, the level of income and the degree of motorization or the availability to use the car for travel.

From the traffic model, the current passenger flows were extracted and are presented in the figures below.

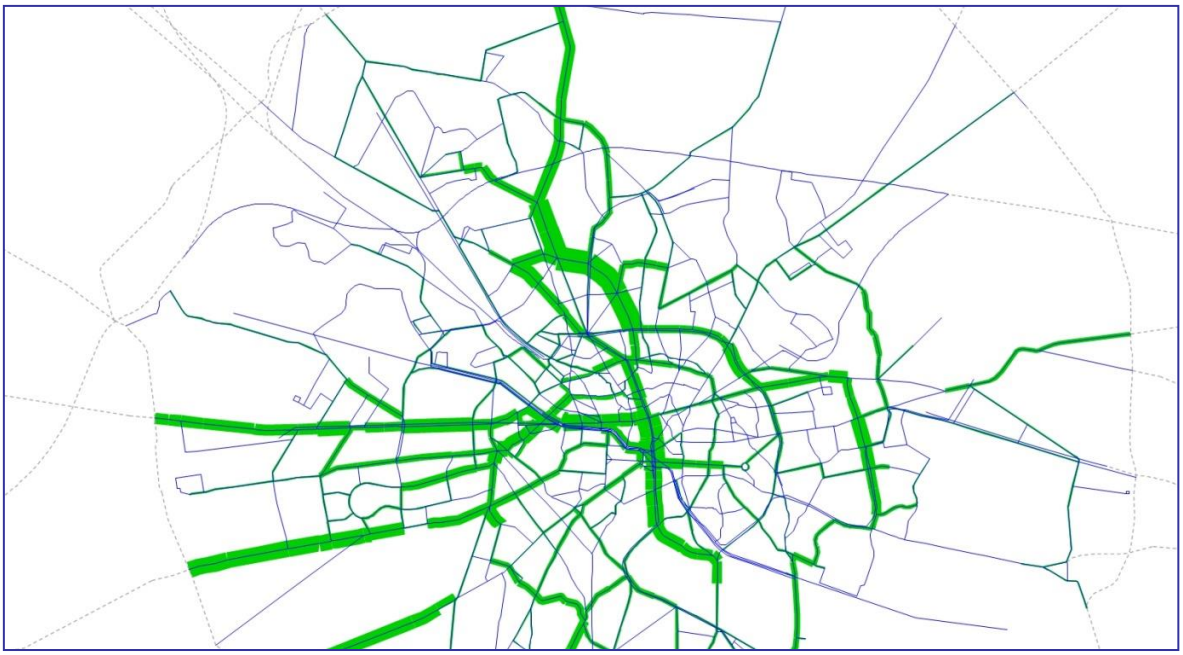


Figure 2. Bus passenger flows



Figure 3. Trolleybus passenger flows



Figure 4. Tram passenger flows

2. PROPOSED SOLUTION

2.1 Establishing the effect of the implementation of lanes dedicated to public transport

Based on the volume of passenger flows, the following routes for the implementation of lanes dedicated to public transport were identified and taken into account in a first simulation phase:

- Bulevardul Elisabeta/Kogalniceanu – Piața Operei;
- Bulevardul Decebal – Piața Unirii ;
- Bulevardul Magheru -Bulevardul Balcescu;
- Razoare – Drumul Taberei;
- Aeroportul Baneasa – Piața Presei Libere – Kisselef – Arc de Triumf – Prezan – Calea Dorobantilor

The estimation of the effect of the implementation of lanes dedicated to public transport was achieved by developing two scenarios:

- the basic situation, without lanes dedicated to public transport
- the scenario in which lanes dedicated to public transport are introduced, for the routes mentioned above.

Table 1. The difference between the number of passengers attracted, on each public transport line affected by the implementation of dedicated lanes

Public transport lane	Traffic direction	Base year	After the implementation of public transport lanes	Percentage variation (%)	Public transport lane	Traffic direction	Base year	After the implementation of public transport lanes	Percentage variation (%)
104	start	10862	15974	47.1	336	start	37764	40546	7.4
104	return	8673	10842	25	336	return	36581	43669	19.4
105	start	7175	10907	52	368	start	11223	18209	62.2
105	return	7755	11655	50.3	368	return	13789	21623	56.8
110	start	8183	6428	-21.4	381	start	54837	67802	23.6
110	return	8839	7888	-10.8	381	return	56383	68618	21.7
116	start	8689	8815	1.5	443	start	144	405	181.3
117	return	13565	14843	9.4	443	return	320	379	18.4
122	start	3343	4710	40.9	444	start	1112	1256	12.9
123	return	14942	18819	25.9	444	return	764	1459	91
123	start	9270	11932	28.7	446	start	594	512	-13.8
124	return	3687	4706	27.6	446	return	330	434	31.5
124	start	3335	4043	21.2	448	start	749	1351	80.4
126	return	942	1095	16.2	448	return	1066	1208	13.3
126	start	1186	1423	20	449	start	850	1031	21.3
131	return	9447	17410	84.3	449	return	1125	1272	13.1
131	start	10873	19759	81.7	450	start	519	579	11.6
137	return	32860	27760	-15.5	450	return	555	695	25.2
148	start	2051	2421	18	451	start	551	732	32.8
148	return	1552	2112	36.1	451	return	681	694	1.9
168	start	7653	9641	26	476	start	469	571	21.7
168	return	4401	6889	56.5	476	return	479	551	15
173	start	9268	7949	-14.2	601	start	12430	14431	16.1
173	return	9628	9230	-4.1	601	return	8968	10924	21.8
182	start	4464	5226	17.1	61	start	11115	12229	10
182	return	6127	7624	24.4	61	return	9761	11527	18.1
205	start	9705	10889	12.2	66	start	35251	38614	9.5
205	return	12730	12348	-3	66	return	46925	47859	2
221	start	3140	3644	16.1	69	start	14643	20832	42.3
221	return	2487	2755	10.8	69	return	19170	28730	49.9
226	start	7839	7314	-6.7	70	start	5268	5570	5.7
261	start	476	456	-4.2	70	return	5834	6576	12.7

Public transport lane	Traffic direction	Base year	After the implementation of public transport lanes	Percentage variation (%)	Public transport lane	Traffic direction	Base year	After the implementation of public transport lanes	Percentage variation (%)
261	return	213	161	-24.4	71	start	1424	1525	7.1
268	start	7899	12804	62.1	71	return	554	878	58.5
268	return	4513	5171	14.6	783	start	6458	6902	6.9
282	start	17606	19790	12.4	783	return	5300	7813	47.4
282	return	18546	19944	7.5	809	start	2121	1468	-30.8
300	start	12571	5435	-56.8	809	return	1788	2069	15.7
300	return	15783	8996	-43	816	start	4936	4651	-5.8
301	start	13121	10347	-21.1	816	return	4793	4028	-16
301	return	13782	9078	-34.1	85	start	2022	2652	31.2
304	return	1006	960	-4.6	85	return	3966	4584	15.6
304	start	766	944	23.2	90	start	4499	6051	34.5
313	return	12560	12369	-1.5	90	return	5081	8059	58.6
330	start	13973	16713	19.6	91	start	9972	15531	55.7
330	return	22229	20145	-9.4	91	return	12644	21717	71.8
331	start	27082	39023	44.1	92	start	522	556	6.5
331	return	28073	42590	51.7	92	return	1536	1742	13.4
335	start	18178	21708	19.4	93	start	3144	4010	27.5
335	return	16692	20853	24.9	93	return	2205	3020	37
Total number of trips before and after the implementation of the project							**952955**	**1122682**	**17.8**

Table 2. The improvement of travel times for each public transport line that benefits from the effect of the introduction of dedicated lanes (expressed in seconds)

Public transport lane	Traffic direction	Base year	After the implementation of public transport lanes	Percentage variation (%)	Public transport lane	Traffic direction	Base year	After the implementation of public transport lanes	Percentage variation (%)
104	start	1698	1509	-11.1	336	start	2324	2108	-9.3
104	return	1887	1703	-9.8	336	return	2323	2153	-7.3
105	start	3064	2861	-6.6	368	start	2692	2424	-10
105	return	3216	2989	-7.1	368	return	2559	2182	-14.7
110	start	2086	1885	-9.6	381	start	2689	2565	-4.6
110	return	2037	1874	-8	381	return	2426	2362	-2.6
116	start	2550	2490	-2.4	443	start	846	672	-20.6
117	return	1846	1774	-3.9	443	return	865	683	-21

Public transport lane	Traffic direction	Base year	After the implementation of public transport lanes	Percentage variation (%)	Public transport lane	Traffic direction	Base year	After the implementation of public transport lanes	Percentage variation (%)
122	start	1877	1534	-18.3	444	start	865	683	-21
123	return	2551	2403	-5.8	444	return	846	672	-20.6
123	start	2333	2189	-6.2	446	start	865	683	-21
124	return	2079	1935	-6.9	446	return	846	672	-20.6
124	start	1947	1807	-7.2	448	start	846	672	-20.6
126	return	2353	2108	-10.4	448	return	865	683	-21
126	start	2386	2242	-6	449	start	846	672	-20.6
131	intors	1776	1215	-31.6	449	return	865	683	-21
131	dus	1573	1044	-33.6	450	dus	865	683	-21
137	return	3268	3129	-4.3	450	start	846	672	-20.6
148	start	865	683	-21	451	return	865	683	-21
148	return	846	672	-20.6	451	start	846	672	-20.6
168	start	2212	1948	-11.9	476	return	865	683	-21
168	return	2497	2068	-17.2	476	start	846	672	-20.6
173	start	2096	2068	-1.3	601	return	1589	1374	-13.5
173	return	2113	2036	-3.6	601	start	1093	918	-16
182	start	3153	3037	-3.7	61	return	2677	2468	-7.8
182	return	2997	2892	-3.5	61	start	2667	2496	-6.4
205	start	1877	1563	-16.7	66	return	2528	2403	-4.9
205	return	1961	1679	-14.4	66	start	2403	2235	-7
221	start	1266	1168	-7.7	69	return	2979	2591	-13
221	return	1230	1119	-9	69	start	2922	2501	-14.4
226	start	2432	2351	-3.3	70	return	2396	2285	-4.6
261	start	1075	891	-17.1	70	start	2295	2122	-7.5
261	return	1220	1103	-9.6	71	return	1660	1519	-8.5
268	start	1998	1503	-24.8	71	start	1958	1809	-7.6
268	return	2335	1980	-15.2	783	return	2402	2029	-15.5
282	start	3377	3177	-5.9	783	start	2688	2135	-20.6
282	return	3322	3158	-4.9	809	return	2296	2280	-0.7
300	start	1526	1386	-9.2	809	start	2252	2247	-0.2
300	return	1426	1369	-4	816	return	3194	3115	-2.5
301	start	1817	1692	-6.9	816	start	2966	2823	-4.8
301	return	1923	1780	-7.4	85	return	2058	1951	-5.2
304	return	1935	1751	-9.5	85	return	1729	1557	-9.9
304	start	1950	1771	-9.2	90	start	3132	2634	-15.9
313	return	1866	1825	-2.2	90	return	3068	2528	-17.6
330	start	2698	2283	-15.4	91	start	2035	1557	-23.5

Public transport lane	Traffic direction	Base year	After the implementation of public transport lanes	Percentage variation (%)	Public transport lane	Traffic direction	Base year	After the implementation of public transport lanes	Percentage variation (%)
330	return	2642	2388	-9.6	91	return	2060	1522	-26.1
331	start	1452	1066	-26.6	92	start	2185	2070	-5.3
331	return	1761	1340	-23.9	92	return	2075	1903	-8.3
335	start	3040	2468	-18.8	93	start	1582	1341	-15.2
335	return	3260	2741	-15.9	93	return	1888	1624	-14
Total number of trips before and after the implementation of the project							**200173**	**178318**	**-10.9**

From the analysis of travel times and the number of passengers in the scenario with and without the project presented in the tables 1 and 2, it can be observed for the transport lines affected by the introduction of dedicated traffic lanes following results:

- the percentage of people who used public transport increased by 17.8%;
- travel times decreased by 10.9%.

3. SOLUTIONS FOR THE IMPLEMENTATION OF DEDICATED PUBLIC TRANSPORT LANES

3.1 Options for dedicated transport lanes

The introduction of dedicated transport lanes can be done by the following methods:

- dedicate lanes to Bucharest Transportation Company (STB) vehicles and taxis in the same direction as the existing traffic. These can be run during the whole day (24 hours/day) or only for a certain period of time (AM and PM peak hours);



Figure 5. Lanes dedicated to public transport

-streets dedicated exclusively to public transport. Depending on the local urban planning conditions and the width of the streets, they are usually found in the centre of the cities. As an example, they were introduced near the areas intended exclusively for pedestrians, in the cities of Birmingham and Leeds in Great Britain
- the lane dedicated to public transport in the opposite direction to the current traffic. In Bucharest, we have an example of this type on Bulevardul Mihail Kogalniceanu.
- the possibility of making some turns (to the left) by STB vehicles, which are forbidden to other vehicles;
- "gates" for public transport. They allow access to some streets only by public transport vehicles and may require markings and indicators or various physical means (bollards that lower when a public transport vehicle arrives, barriers, etc.)



Figure 6. Gates for buses in order to prevent the access of cars

- "park and ride" facilities - Parking lots located near a congested area or even at the beginning of the localities intended for drivers who will continue their journey with public transport. This type of measures is accompanied by the increased development of lanes dedicated to public transport vehicles.



Figure 6. Example of transfer parking - interchange point, for travellers, between public and private means of transport

- prioritizing public transport at signal control junctions

4. CONCLUSIONS

In this article, an analysis of the possibility of introducing lanes dedicated to public transport on several streets in the municipality of Bucharest was elaborated. Through the implementation of such solutions, a change in the modal distribution can be observed by increasing the use of (local) public transport at the expense of the use of the car. It must be stated that the implementation of such solutions also requires an additional infrastructure, which offers the appropriate parking possibilities for vehicles as well as the option for public transport to have priority at signal control junctions.

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