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Contemporary Issues of Urban Mobility

Abstract:

Consequences of individual transport rapid development are a threat for modern cities and their population. Actually, transport problems in urban areas mostly derive from inadequate solutions of urban mobility by local transport systems. Majority of these problems are caused by extreme density of motor vehicles in urban areas. Increase of motor vehicles is a consequence of income increase and better standard of living. Accordingly, theoretical part of this study will investigate and elaborate on modern problems of urban transport, while the practical part of this work gives an overview of concrete solutions to some of the problems of urban transport on the example of the city of Rijeka in Croatia. Results of research also suggest guidelines for more efficient transport management in cities of similar size.

Keywords:

city, urban mobility, motor vehicles, transport systems, transport problems

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Introduction

Consequences of individual transport rapid development are a threat for modern cities and their population. Actually, transport problems in urban areas mostly derive from inadequate solutions of urban mobility by local transport systems. Majority of these problems are caused by extreme density of motor vehicles in urban areas. Increase of motor vehicles is a consequence of income increase and better standard of living. For the sake of ensuring enough space for motor vehicles, houses are being torn, trees get cut down, roads are getting wider and pedestrian areas are narrowed; road crossings and pedestrian roads, green areas and emergency access spaces are being used for parking; air pollution is becoming unbearable and the noise is ever increasing; flow and speed of public transport are decreased due to cars, while construction of new transport infrastructures costs space and money, so the quality of life in cities is getting lower.

Urban transport in these circumstances hardly comes to terms with demands of fast, safe, comfortable and economical transportation of people and goods. In order to change this, basic transport problems should be indentified and then solved according to size and type of the city.

Theoretical framework and research problems

Large cities and growing number of urban population in the world is a 20th century phenomenon. The century behind us will be marked by decline from poverty for majority of world's population. The number of people in the world migrating into cities is larger every day. 80% of European population lives in urban areas. It is therefore estimated that by year 2050 some 80% of all population of the Northern Hemisphere will be living in the cities, while the percentage will fall to some 55% to the south of the equator. Such facts impose further challenges for urban traffic, and directly bound the development of commerce to the possibility of urban and suburban traffic.

First half of the 20th ct is marked by intense growth of cities in developed European and North American countries, while in the second half the cities are growing in countries in process of development, especially in Latin America and Asia. Thus, the largest cities in the world in the beginning of the 21st ct are those from the Third World. Urban transport is developed in cities with population over 100.000 people, but also in many with smaller population. Over one billion people are using urban transport daily. Without a doubt, this is the most frequent form of transport. Today, each city is organizing their own transport according to their own means and demands, so it is hard to come up with similiraties or unification of world urban transport.

Cities can be categorized based on organization of their transport [1]:

Third World city - economic underdevelopment, social backwardness, great population density, but low regular employment and mobility. All infrastructures are poorly developed, transport included. Streets, which are not primarily meant for motor transport, are where life is happening, while transport is mainly pedestrian, with cheap personal vehicles abounding (bikes and motorbikes), and even carts (in India, for example). Car is owned by minority of population. Public transport is unsatisfying, often too crowded and mostly executed by bus. Some of the largest cities of this type have begun developing metropolitan railway system.

Car city - relatively new cities in highly developed countries, constructed mostly after mass production of cars. Typical cities of this sort are those in southwest and midwest of the USA, in Canada and Australia. There is low population

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density (mostly individual type residencies), high mobility of employed residents, specialization of urban spaces and occasional visits to shopping malls. Majority of population is motorized, and almost every type of movement is done by car. Public transport is irrelevant, and it usually consists of infrequent bus service. Unmotorized people are less mobile and dependent on others in terms of transport. American way of life doesn't only imply progressive use of cars, but American reliance and dependence on cars could almost be called religious, while victims made in the name of this religion are often irrational. Using their cars to escape the metropolis, Americans have only managed to transfer the chaos of overcrowded city onto the road, with nature disappearing under tarmac.

Western European city - this type of city ows its physical structure to a long process of development, population density and infrastructure are relatively high, and functions of urban areas mixed up. It is not completely adapted to car transport (and without destructive remodelling on a big scale it cannot be so), so in spite of highly motorized population, car use is somewhat limited, so public transport is important and frequently used. More or less, city politics is focused on subsidizing public transport, while mildly restricting or destimulating personal car transport.

Socialist city - mainly found in Russia and parts of Eastern Europe. Mostly these are newly built cities, although there are many with physical structure similar to Western European cities. Motorization is pretty low, due to low standards of living, population density is relatively high and public transport was forced for functional and ideological reasons.

Asian capitalist city - this type of city can be found in Japan, South Korea and highly developed areas such as Singapore or Hong Kong. High population density and developed infrastructure, along with some collectivistic cultural patterns, leads to mass use of public transport and to rather restrictive policies regarding personal car use, in spite of private capital domination.

Of course, not every large city in the world can be put in these clearly defined categories - many of them have particularities of several different types. The complexity of transport system depends on the size and type of city. Main transport issues are usually related to urban areas. Some of the most notable urban transport are following [2]:

1) Traffic congestion and parking difficulties. Congestion is one of the most prevalent transport problems in large urban agglomerations. It is particularly linked with motorization and the diffusion of the automobile, which has increased the demand for transport infrastructures. However, the supply of infrastructures has often not been able to keep up with the growth of mobility. Since vehicles spend the majority of the time parked, motorization has expanded the demand for parking space, which has created space consumption problems particularly in central areas; the spatial imprint of parked vehicles is significant. Congestion and parking are also interrelated since looking for a parking space (called "cruising") creates additional delays and impairs local circulation. In central areas of large cities cruising may account for more than 10% of the local circulation as drivers can spend 20 minutes looking for a parking spot. Parking takes up as much as 24% of the area of American cities, and some urban areas have as many as 3-5 parking spaces per car; even so, people looking for parking account for 30% of miles driven in urban business district (The Economist, Auugust 1sth 2015.).

2) Longer commuting. On par with congestion people are spending an increasing amount of time commuting between their residence and workplace. An important factor behind this trend is

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related to residential affordability as housing located further away from central areas (where most of the employment remains) is more affordable. Therefore, commuters are trading time for housing affordability. However, long commuting is linked with several social problems, such as isolation, as well as poorer health (obesity).

3) Public transport inadequacy. Many public transit systems, or parts of them, are either over or under used. During peak hours, crowdedness creates discomfort for users as the system copes with a temporary surge in demand. Low ridership makes many services financially unsustainable, particularly in suburban areas. In spite of significant subsidies and cross-financing (e.g. tolls) almost every public transit systems cannot generate sufficient income to cover its operating and capital costs.

4) Difficulties for non-motorized transport. These difficulties are either the outcome of intense traffic, where the mobility of pedestrians, bicycles and vehicles is impaired, but also because of a blatant lack of consideration for pedestrians and bicycles in the physical design of infrastructures and facilities.

5) Loss of public space. The majority of roads are publicly owned and free of access. Increased traffic has adverse impacts on public activities which once crowded the streets such as markets, agoras, parades and processions, games, and community interactions. These have gradually disappeared to be replaced by automobiles. In many cases, these activities have shifted to shopping malls while in other cases, they have been abandoned altogether. Traffic flows influence the life and interactions of residents and their usage of street space. More traffic impedes social interactions and street activities. People tend to walk and cycle less when traffic is high.

6) High maintenance costs. Cities with an aging of their transport infrastructure are facing growing maintenance costs as well as pressures to upgrade to more modern infrastructure. In addition to the involved costs, maintenance and repair activities create circulation disruptions. Delayed maintenance is rather common since it conveys the benefit of keeping current costs low, but at the expense of higher future costs and on some occasion the risk of infrastructure failure. The more extensive the road and highway network, the higher the maintenance cost and the financial burden.

7) Environmental impacts and energy consumption. Pollution, including noise, generated by circulation has become a serious impediment to the quality of life and even the health of urban populations. Further, energy consumption by urban transportation has dramatically increased and so the dependency on petroleum. Yet, peak oil considerations are increasingly linked with peak mobility expectations where high energy prices incite a shift towards more efficient and sustainable forms of urban transportation, namely public transit.

8) Accidents and safety. Growing traffic in urban areas is linked with a growing number of accidents and fatalities, especially in developing countries. Accidents account for a significant share of recurring delays. As traffic increases, people feel less safe to use the streets.

9) Land consumption. The territorial imprint of transportation is significant, particularly for the automobile. Between 30 and 60% of a metropolitan area may be devoted to transportation, an outcome of the over-reliance on some forms of urban transportation. Yet, this land consumption also underlines the strategic importance of transportation in the economic and social welfare of cities.

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10) Freight distribution. Globalization and the materialization of the economy have resulted in growing quantities of freight moving within cities. As freight traffic commonly shares infrastructures with the circulation of passengers, the mobility of freight in urban areas has become increasingly problematic. City logistics strategies can be established to mitigate the variety of challenges faced by urban freight distribution.

Research results and discussion

Cities deal with aforementioned problems differently, but mostly they try to relieve the centres from motor transport, especially individual motor transport. Shopping areas, districts and streets are recently being turned into pedestrian zones. Intercity traffic is lead through detours outside of cities. The cities are having their streets widened in order to increase the traffic flow. Mass transport is usually done by specific fast form of urban transport, most successfully by subway trains and high speed city trains. Individual car use is kept to periphery, but individual transport is mainly turned to public transport. There are attempts to improve the traffic situation by investing in high tech signal devices, with ability to control them in any given moment, according to needs. Traffic is being monitored through system of video monitoring. The most radical changes are those that deal with the very structure of the city. Efforts are made to avoid the classic centre - periphery orientation. Largest success was made with organization of metropolitan areas. Extremely important issue of urban transport is static traffic. Modern solutions are mostly aimed at multi-storey parking garage at the city centre, while open parking lots are built towards the periphery. Similar parking lots are built next to greater facilities, such as shopping malls, business centres and like.

In the following, problems in traffic system of the city of Rijeka will be discussed, as well as possible solutions. Rijeka is sprawled in length of about 16 km, and of 1 to 2 km in width (5,5 km in the centre). Area of the city measures about 44 km2. Industry and business is mostly situated at the centre or in the north-east. Such elongated shape defined the road system, which is longitudinal. Streets parallel with coastline had a technical advantage during construction - they were built over relatively flat terrain, while technical elements of transverse streets were rather bad (longitudinal gradients, radius of curves). Undersize of traffic network, lack of spare space for further construction, development of residential areas and industrial zones at the radial road network emanating from the city centre, and the ever growing motorization has lead to following problems.

Traffic congestion and parking problems in Rijeka. According to population census from 2011, there are 128.000 people living in Rijeka, or 40.000 less people than in 1991. In 2011 there were 68.945 registered vehicles in the city. The System of Automatic Control in the city registrates about the same number of vehicles entering Rijeka on a daily basis. This number of vehicles turns out to be too much for city traffic system, especially during peak periods. For example, average speed in urban traffic in the city of Rijeka in 2002 year during rush hour in certain routes was only 2 km/h. The increase of vehicle flow through intelligent solutions, better parking organization, recent construction of roundabouts and new infrastructure solutions improved the city traffic. The efficiency of infrastructure solutions was best confirmed by construction of Rijeka detour that is one of the best-used roads in the Republic of Croatia. This detour is very important for the city traffic system, because majority of transit traffic passes here, as well as part of local traffic and so

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operates as the city highway. Automatic traffic control system has enabled a complete use of throughput capacity of city road network (in real time). Thus, thanks to automatic control system and construction of a four-track roundabout from Krizisce to Matulji in 2010, traffic congestion was largely reduced.

Lack of parking spaces, along with traffic congestion, was the main feature of traffic in the city of Rijeka. Solution was at first sought by increasing the number of payed parking spaces. The number of payed parking spaces has increased by 3,5 times compared to 1991. Currently Rijeka has about 6.000 parking spaces located within 5 to 10 min walk outside of major urban public facilities.[3] Lack of parking spaces, for the time being, is compensated by organizing parking within the central zone in a different manner, installing protective pillars to prevent irregular parking, constructing public garage facilities with capacity of 1.550 parking spaces and by increasing the charge of parking.

Public transport inadequacy. Favourable maritime location and railway passing through the city are not sufficiently used for public transport. Several suggestions were made to build a city public railway system, but were dropped. There are 48 routes offered for urban and suburban trains which would run from 04 to 21 hrs. The intended daily capacity of a line would be over 30000 passenger places, which makes almost one third of average number of passengers which are daily transported in public urban and suburban traffic of city of Rijeka.[4] From the economical aspect it is highly questionable how the population, i.e. number of users of public urban transport, reflects to introduction of new traffic technologies into Rijeka's urban traffic. Urban and suburban railways are suitable for cities with more than 500 000 inhabitants. In Rijeka public transport service is provided by Autotrolej Ltd. (by bus) and taxi services. Demand for public transport in the city and its suburbs can be seen in Table 1.

Year	Trversed km	Transported passengers	Number of transported passengers per km
1909.	454,8	2 584,1	5,68
1920.	425,9	2 600,7	6,11
1930.	622,1	4 216,4	6,78
1940.	867,2	8 260,4	9,53
1950.	598,8	10 446,6	17,45
1960.	4 954,5	29 911,0	6,04
1970.	7 660,0	45 294,0	5,91
1980.	10 617,2	57 609,0	5,43
1990.	12 354,0	87 801,0	7,11
2000.	9 481,0	35 213,0	3,71
2010.	9 674,4	46 129,5	4,77
2013.	9 312,2	45 656,8	4,90

Table 1. Indicators of public transport in the 20th and the 21st ct (the Noughties).

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The need for such services in Rijeka's urban traffic has decreased considerably in the last two decades, mainly because the number of people employed in the city of Rijeka has diminished, and so has the number of pupils in elementary and secondary schools. The number of people employed in the city of Rijeka in 1991 was 79441, compared to 49337 employed in 2010. The number of pupils in elementary (22445) and secondary (11048) schools amounted to 33493, while in 2014 there were total of 15258 pupils, i.e. 8433 in elementary and 6826 in secondary schools.

Decrease of all types of demand for services of public urban transport in the city of Rijeka has resulted in decrease of supply, i.e. number of buses used in public urban and suburban traffic, from 266 in the year 1990 to only 180 in the year 2013. Motor pool from 31 December, 2014 consisted of 174 vehicles, of which 104 were regular buses, 47 joint buses, 19 minibuses, 3 vans and one double-decker.

Difficulties for non-motorized transport. Rijeka is practically the city of cars. Bike transport is underdeveloped, while pedestrians are often faced with difficulties because of irregularly parked cars.

Environmental impacts and energy consumption. Air pollution monitoring in Rijeka has begun in the Seventies. Traffic was then not particularly considered as an air pollutant. Today traffic is a great source of air pollution (Table 2).

Firms	SOx(t/year)	Nox(t/year)	CO(t/year)	CO2(t/year)	Particle(t/yr)
INA-Urinj	4154	2365	179	863358	67
INA-Mlaka	0	9,4	4,7	8319	0,2
DINA-Omišalj	143	26	1,6	16674	4,4
U.C. Energo	48,3	47,37	7,42	24516	0,01
Non-industrial combustion	343	272	8375	-	287
Road traffic	288	5528	4722	531	193

Table 2. Statistics for emissions in the county Primorsko-goranska

Solution to this was sought in introducing gas fuelled buses in 2013. These buses have lower emissions of CO2, are air-conditioned, have ramps for the disabled and are much more economic since gas is cheaper than traditional fuel.

Loss of public space. In European cities road infrastructure takes up 10 to 20% of urban area, in underdeveloped countries only about 10%. In cities oriented to motorized traffic, about 30% of urban area is meant for road system and about 20% for parking spaces. Traffic areas in Rijeka take a large space, which is recently slowly being returned to pedestrians. For example, the great pier in the very centre of the city was closed to general population as a part of customs area, and now, after more than 50 years, the 2 km long promenade Molo Longo is again open to public. Also, part of Karolina Rijecka Pier has been reopened to citizens after being used as a parking lot for many years.

High maintenance costs. Maintenance costs of urban roads have important and wide social-economic repercussions. Shortening travel time is related to good road maintenance, which is widely accepted as one of the most important factors for development of the city. Annual communal

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infrastructure maintenance costs in Rijeka amount to about 11 million euros, of which about 2 million euros goes to road maintenance.

Accidents and safety. According to state statistics, the majority of accidents in Croatia in 2013 happened on roads within settlements (72,5%), and state roads outside of settlements (9%). Equally, the largest number of people killed in traffic accidents happened on roads within settlements (141 people) and state roads outside of settlements (80 people).

Land consumption. Traffic uses up expensive city space. Between 30 and 60 percent of a metropolitan area may be devoted to transportation.

Freight distribution. Daily, throughout the twenty-four hours of the day, and along with people, the variety of goods of different characteristics, sizes and quantities, ranging from tiny boxes to large containers flow through a city. Research made in the West European countries shows that the demand of consumer goods in the cities today exceeds one tonne per year per capita.

Urban transport challenges are linked with the dominance of the automobile, which will certainly continue, at least up to 2030. What follows is an estimation of the number of cars in Rijeka till 2030. In the period of only 11 years, from 1997 to 2008, the number of registered cars in Rijeka has increased for 23527, i.e. from 50241 cars registered in year 1997 to 73768 registered cars in year 2008. After the recession, in the period of only five years, the number of cars in Rijeka has dropped for 11.970. Accordingly, for the period between 1997 to 2013 regression analysis was made to explore the relationship between registered cars (NRC) and the movement of GDP. The numerical computation was performed by Statistica software (cf. Table 3).

N=17	Regression Summary for Dependent Variable: NRC (RKA_auto) R= 0,95349279 R2= 0,90914851 Adjusted R2= 0,90309174 F(1,15)= 150,10 p<0,00000 Std. Error of estimate: 2440,7					
	Beta	Std. Err. Of Beta	B	Std. Err. Of B	T(15)	p-level
Intercept			3849,404	4900,929	0,78544	0,444423
GDP	0,953493	0,077825	0,215	0,018	12,25172	0,000000

Table 3: Results of regression analysis

Regression analysis of the correlation between NRC and the GDP gives the following model of simple linear regression:

$$NRC = 3849,4 + 0,215\ GDP \qquad (1)$$

Results of regression analysis (cf. Table) indicate that there is a statistically significant correlation between NRC and the GDP (R=0,953; F(1,15)=150,1; p<0,01). Correlation between the NRC and the GDP is positive, indicating that the increase in NRC is linked with an increase in GDP. An increase in GDP with 90% of variance can be explained by GDP. Application of the mentioned model for planning the movement of the number of employees is shown by Chart 1.

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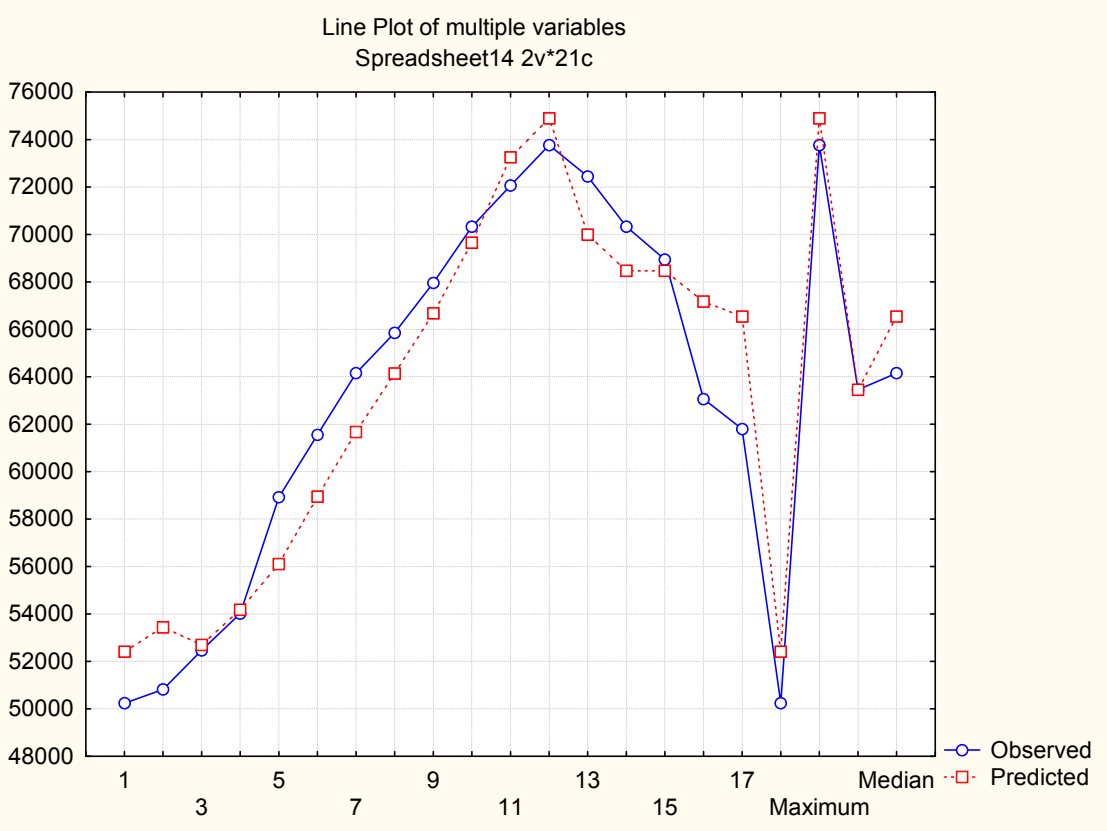

Chart 1. Comparison of results obtained by using econometric model and real data on the movement of the number of register cars in Rijeka from 1997 and 2013.

Based on the given model (1), an estimate of the number of register cars in the Rijeka by 2030 was made (cf. table 4).

Year	*Number of register cars*
NRC_{2015}	69219
NRC_{2020}	76023
NRC_{2025}	83535
NRC_{2030}	91828

Table 4. Estimate of the total number of register cars in Rijeka by 2030

On assumptions that the average growth rates of GDP will be 2%, the number of registered cars in Rijeka by 2030 will be NRC2030 = 91 828. As far as existing developing and urbanistic trends are continued, it is estimated that the number of cars in Rijeka will increase for about 30.000 till 2030, and other solutions for mobility of citizens will have to be found. One of these is the development of the Park&Ride system. The basis of this system is a network of well arranged and easily accessed parking lots located in key points around the city and connected to the city centre by fast and frequent bus transportation, with the bus ticket being included in the charge for parking. This would make such parking lots more economic solutions for drivers - compared to expensive parking lots in the city centre. But this system is to be carefully planned and co-ordinated with local companies. To relieve

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the city centre from cars, it is necessary to charge the parking there more, but also to ensure cheaper and functional transport by bus. Automatic traffic control system and further development of intelligent transport systems could influence the optimization of traffic flow in the future. However, what really matters in the end is to ensure quality and availability of implemented systems, which includes easy access to all important city facilities. This can be done by thorough reurbanization, taking into account metropolic influence of Rijeka on areas surrounding it.

Conclusion

It is unthinkable for a city to function without quality urban traffic. Urban traffic contributes to economic development of cities and their social upgrading, and vice versa. Urban transport challenges are linked with the dominance of the automobile, which will certainly continue, at least up to 2030. The number of cars in Rijeka will increase for about 30.000 till 2030, and other solutions for mobility of citizens will have to be found. One of these is the development of the Park&Ride system. To relieve the city centre from cars, it is necessary to charge the parking there more, but also to ensure cheaper and functional transport by bus. Automatic traffic control system and further development of intelligent transport systems could influence the optimization of traffic flow in the future. However, what really matters in the end is to ensure quality and availability of implemented systems, which includes easy access to all important city facilities. This can be done by thorough reurbanization, taking into account metropolic influence of Rijeka on areas surrounding it.

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