Efficient Transport System in Urban Environment

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Abstract: Many cities are currently facing to problems with the functioning of their transport infrastructure resulting mainly from congestions and the increasing trend of individual car usage. The call for solving and proposing the efficient transport systems occurs due the fact of need to improve the mobility condition in the urban environment. Therefore, this paper deals with the topic of efficient transport system with accent to evaluation of single transport modes and their impact on the urban environment. The two parameters are proposed: the Capacity Index (CI) and the Vehicle Emission Pollutant Index (VEPI) that present how efficient the transport systems are in first case in the sense of transport infrastructure capacity, second in the sense of environmental issue.

Keywords: efficient, transport systems, urban, environment

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1. Introduction

The efficient public transport is not only related to the term of efficient as power and energy saving, but also saving the money of public authorities, citizens taxes and saving the environment. [5] This study presents the overview of research studies dealing with evaluation and analysis of various means of transport. [13, 15] This is important for evaluation of various approaches in order to ensure the objective way focused on this topic.

2. The transport systems characteristics

In the current time are presented in the urban environment mostly the following modes of transport:

- Car,
- Public transport
- Walking,
- Cycling.

The general advantage of public transport to serve for more passengers is facing to the basic problem of flexibility and problem of the "door to door" effect. That means the citizen will prefer the individual form of transport because it is more flexible and it can be used from "door to door" base. From the point of view of personal usage we can distinguish public and individual forms of transport. In Table 1 are shown the basic characteristics of presented modes of transport. Even walking and cycling have less space consumption in comparison to car, the problem of these modes of transport is that they are suitable for short distances. Especially for cycling is also need for parking facilities which are not always available in same volume as for cars.

Table 1. The comparison of particular transport systems characteristics

mode	Indiv. vs. public	parking	distance	Door to door
car	individual	yes	long	yes
PT	public	no	long	no
cycling	individual	yes	short	yes
walking	individual	no	short	yes

Cars, walking and cycling are likely to be individual forms of transport, public transport to be public form of transport. But in last decade there are presented also mixed types as carpooling, carsharing, bikesharing.[4] The theoretical advantage of public transport as ability to service to more passenger as car is generally known, but there are many factors which are necessary to take into account for understanding why the public transport has the declined trend. The study [11] defined various demand factors that have an influence on the demand for public transport. The study [10] states that in the situation where urban travel patterns become more complex, it generally becomes more difficult to serve those trips adequately by public transport and patronage levels tend to suffer as a result. By way of evidence, the results show that private transport users have the ability to react more rapidly to changes in the distribution of origin and destination activities than their public transport counterparts and this tends to confer significant advantage to users of that mode.

Moreover, the current knowledge on residential dissonance and travel behaviour indicates that the success of land use based policies is largely determined by the composition

of consonant and dissonant residents living within a neighbourhood [8]. Researchers have generally adopted two approaches to disentangle the self-selection effect in establishing the causal link between environmental factors and travel behaviour. In the analysis of cross-sectional data, residential self-selection effects are controlled by taking into account a measure of travel attitudes/preferences and socio-demographics, and investigating their potential linkages.

3. Transport planning issue

There is no doubt that the systematic transport planning plays a significant role in the process of function of all transport systems in urban evidence. But the local conditions differ from city to city. Therefore, we can find the differentness between the goals in strategic documents as master transport plan and in reality where the transport systems and specially the car usage is limited just only in few ways. The study [2] provided the interesting findings in determining the basic mistakes of transport planning which are the following:

- Differentness between the proposed master plans or systematic documents and adopted measures.
- Lack of integration strategy.
- Weak participation of responsible authorities in problem solving.
- Unrealistic time scheduling for implementation.
- Lack of monitoring the strategy.
- Mostly the technical strategy is outsourced.
- Lack of data used for systematic transport planning.
- Scale of the plans and strategy.
- Lack of finance.
- Absence of interest in solving the systematic approach.

From the results shown above it is clear that the transport planning plays the important role in the process of defining the function of transport systems in the city. For example, if the city has the goal to have modal split in favour of public transport to 60% it is a problem if the city still creates the new parking places for cars and reduces the budget for public transport. Such kind of goal will not be achieved in such kind of progress. A good example can be seen in cities which are likely to implement their transport strategies in a positive way, for instance Zurich, Oslo or Odense. [7, 16, 17]

3.1. Public transport

It is proved [1] that the user satisfaction varies among different cities which have different conditions. (nie je naznačená súvislosť)The study [14] did analysis of travel time of public transport. They (kto?) found that a monopolistic, integrated service organisation was correlated with higher user satisfaction. This finding was statistically significant after controlling for a number of individual and local circumstances. The requirements of the advanced PT model (e.g. inclusion of exact departure/arrival time and various route optimisation settings) may be overwhelming

for a standard user to implement in a standard GIS. Thus, not only open data but also open route search interfaces providing the necessary algorithms and computational resources on servers, make such massive analysis feasible. Indeed, reliable spatial analyses of multimodal transport — which for long have been too data hungry and computationally intensive to calculate over large extents — are now more realistic for a larger group of researchers and practitioners than what they used to be.

3.2. Developing the condition for cycling

One predominant aspect of the documents studied is that these strongly associate cycling with a positive urban vision. Negative depictions, for instance, with regard to car driving, or morally underlined claims are nowhere to be found. [3] The choice of researchers includes studies about healthy cyclists – mothers with young children, elderly, people belonging to different religious groups, overweight cyclists, as well as men in business suits –, all moving leisurely or at brisk speeds in different weather situations, conveying the message that bicycling is a cultural norm and pleasurable for everyone. Many researchers also show large numbers of bicyclists, suggesting that bicycling is a mass phenomenon. [6] In the case of Copenhagen, internal pressure to build more cycle tracks grew during the bicycle renaissance period in the late 1970s and early 1980s, when the voice of cyclists became increasingly heard in public debates. They formulated many of the policies and strategies for the bicycle city Copenhagen, and it was recognised for strong will to implement infrastructural change even in the face of resistance. The city had far-reaching ambitions, such as the goal to achieve a 50% share of commuting trips made by bike. The results point on the fact that if good infrastructure is available it can attract also more cyclists.

3.3. Environment issue

Considering the fact of traffic pollution within urban area we can compare also the range of pollution from various means of transport.

In table 2 are compared the pollutants as CO2, PM for solved means of transport.

Table 2. Comparison of pollution within modes of transport

mode	capacity	CO_2 for 10 km	CO2 per prs	PM	PM per prs
bus	100	2.1	0.021	0.13	0.0013
car	5	1.6	0.32	0.25	0.05
walking	1	0	0	0	0
cycling	1	0	0	0	0

We can see the calculation of pollution with regarding of the number of person where the bus is presented with lower range of pollution in comparison of car with theoretical occupancy with 5 persons per car. Moreover the walking and cycling are the clearest modes of transport. Similar we can evaluate also the energy consumption where the cycling and walking represent the lower energy consumers and in opposite the car user the higher consumers.

3.4. Infrastructure capacity issue

From the point of view of the evaluation of transport network which has its own limits on capacity i.e., a limited amount of vehicles can use the infrastructure within time it is a crucial to focus and evaluate the capacity. Let's theoretically consider the junction with arm which allows for 40 second of green time the passing of various types of vehicles (the whole phase takes 90 seconds). For cars, the 32 vehicles can use the green time, which with full occupancy of 5 persons, represents the 160 person per green time. If the whole cycle takes 90 second, in one hour the maximum of 40 cycles can be realized.

Therefore the total amount of persons who will pass the junction is 6400 persons. In the comparison only 12 buses can uses the same green time with capacity of 100 persons. The one green time allow passing of 1200 persons, but with considering the 40 repeating phases it counts for 48 000 persons, see Figure 1.
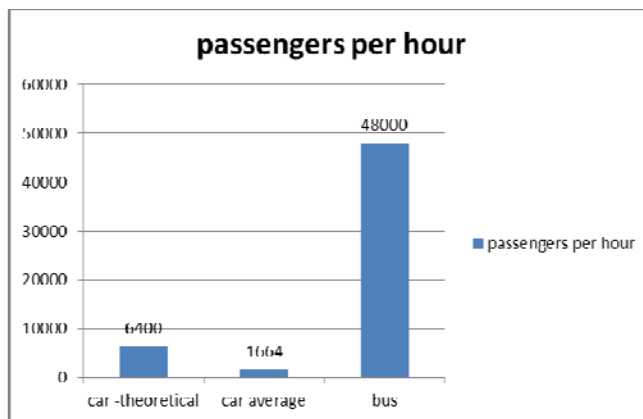

Figure 1. A theoretical comparison of vehicle capacity per one hour at junction.

Now we must say that in reality the traffic is mixed, but in theoretical comparison the efficient usage of time and capacity plays in favour of buses. Also the full occupancy in one car is more or less theoretical that means the average occupancy for a car is around 1.3 person. From this topic it is a clear advantage of public transport. If we continue in space consumption comparison we can find that the length of queue of car will be much longer that of buses.

Moreover for cyclists and pedestrians it is characterized that also in hard condition, i.e. the congestion, their traffic flow will spread out faster and will not create traffic jam as in case of cars. The benefiters are not only the passenger but all services and also for instance the freight cargo [9] serving to the city.

3.4. What is efficient for urban?

In the considering and evaluating what is efficient for the urban environment we can take into account the result presented above. The real efficient transport system is characterized by:

- fully functional transport service abilities,
- minimum of space requirement if the ratio space by persons is taken into account,
- minimum of power or energy consumption,
- minimum of public finance requirement,
- ability to serve in any location for any passenger without recognition the socio-economic status,
- minimum of unused time in operation (i.e. parking issue),
- flexibility,
- ability to cooperate with other means of transport.

For evaluation of these above mentioned factors it is recommended especially for municipalities to update and monitor their own systematic and strategic goals and to ensure if the mobility in the city corresponds to the goals which are stated in such kind of policy.

Especially for public transport it is crucial to represent one public transport system which is integrated [12,13] and does not look like a competitor in this market (for instance, the role of bus and railway.

4. Methodology for efficient analysis of transport systems

We can implement the described characteristics of particular transport systems in parameters which can be used for evaluation of efficiency of transport systems. For that reason the following parameters are proposed:

- Capacity Index (CI_i) which represent the ratio of vehicle units VU of means of transport i with particular occupancy O passing the particular distance per time t

$$\{CI\}_i = \frac{(VU_i * O)}{t} \qquad (1)$$

The capacity index (CI) shows the efficient usage of transport infrastructure per time. For instance, the 4 buses with occupancy of 80 passengers and 8 cars with occupancy of 3 passengers are passing the junction per green time 20

seconds. The capacity index for bus CI_{BUS} will be calculated as:

$$\{CI\}_{BUS} = \frac{(4*80)}{20} = \frac{320}{20} = 16 \qquad (2)$$

In the same way we can calculate the CI for a car.

$$\{CI\}_{CAR} = \frac{(8*3)}{20} = \frac{24}{20} = 1,2 \qquad (3)$$

So we can see that the capacity index for a bus is higher than the capacity index for a car. The number of vehicles passing the particular distance (junction, etc.) is calculated according the basic equation of calculation the for signal timing. That means higher value of the CI represents more efficient system.

In a similar way is proposed the Vehicle emission pollutant index (VEPI) which corresponds to the number of vehicle units (VU), L   is the length of a trip in km, occupancy (O) in number of persons, pollutant parameter   per kilometre (PP) which can be CO2, SO_x, PM^x or other in g per km.

$$VEPI_i = \frac{(VU * L * PP)}{O} \qquad (4)$$

The VEPI indices how un- environmental is the particular mode of transport which means if the value is higher the means of transport has more negative impact and produce more emissions.

5. Conclusions

This paper presents the topic of efficient transport system from various aspects which were taken into account. The conclusion says that the most efficient transport systems should be preferred from the municipality point of view by the implementation of goals of strategic transport planning policy. That means the continuous reducing of the negative impacts of transport modes.

Two indexes are introduced in analysis, the Capacity Index (CI) and the Vehicle Emission Pollutant Index (VEPI). Moreover there are big challenges in the more detail quantification of parameters which could be more understandable for municipalities in order to move them to the realization of their strategic goals leading to the sustainable mobility.

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