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TRAVEL TIME ANALYSIS - CASE STUDY OF NOVI SAD

Keywords
Travel time
Dwell time
Public transport
Cycling

Abstract
Research has shown that people are more likely to choose a transport alternative that offers a shorter travel time than a passenger car. The simplest and most commonly used method for determining travel time is a survey of citizens. This method is prone to subjectivism, and the results obtained are imprecise. In Novi Sad, the travel time from the origin-destination trips was recorded using the global navigation satellite system for the following transport modes: walking, bicycle, passenger car, taxi and bus public transport. In this paper, a comparative analysis of travel time was used to assess the competitiveness of alternative modes of transportation with a special emphasis on the time that passengers spend in a state of rest.

1. INTRODUCTION

In urban areas, modern industrial society has led to a greater flow of people and information. One of the challenges of modern cities is to fit the daily migration of the population into sustainability standards, which should push the passenger car to the

margins of the modal distribution [1,2,3]. In order to achieve this, alternative transport modes must be competitive with the passenger car. The choice of transport mode is influenced by a number of factors such as: price, availability of transport in space and time, comfort, travel time, reliability, safety and others [4,5,6].

Findings of Horrey [7] suggest that even though households acquire at least one car, some are more likely to keep using public transit to commute whenever it provides competitive services in terms of travel time.

One of the important factors when choosing the transport mode is, among other things, the travel time [8]. In order to improve alternative transport modes, it is necessary to analyze and improve the service quality, in the area of travel time. Two characteristics affect the complexity of determining and analyzing the travel time of citizens.

First of all, travel time is a complex parameter and consists of a number of time components. The structure of travel time also depends on transport mode. If it is taken into account that a significant number of trips are realized in a combination of two or more different transport modes, the problem becomes even more complex.

Secondly, in practice, the exact determination of the travel time of each participant is a problem. The simplest and most commonly used method for determining travel time is a citizen survey. This method is prone to subjectivism, and the results obtained are rather imprecise. A detailed analysis of the time components characteristics of the trip is almost impossible to perform based on the data from the citizen survey.

For the purposes of a detailed analysis of travel time and its time components, the movement of citizens was recorded for different transport modes in Novi Sad. Within this work, a comparative analysis of the total travel time and time components for different transport modes (passenger car - PC, bus passenger transport – PT, taxi, bicycle, walking) was carried out, with the aim of determining the current situation, problems, as well as opportunities for increasing the competitiveness of bus PT (passenger transport) and bicycles in relation to PC in Novi Sad.

2. METHODOLOGY

The travel time recording from the origin to the destination was carried out in Novi Sad for the following transport modes: walking, bicycle, passenger car, taxi and bus public transport. 5 researchers participated in the research, one for each transport mode. The researchers are residents and permanent users of the transport mode assigned in the experiment. All researchers moved from a common source on the outskirts of the city (address: Novo naselje, Ulica Braće Dronjak no.10) to the same goal in the innercity core (address: Trg slobode - monument to Svetozar Miletić). The movement routes were not defined in advance, so that the exact length of the route in question differs from the transport mode and it is about 5 km.

The survey was conducted on Wednesday, October 12 2022, between 2 and 3 p.m. during the time after the midday peak load. All researchers started moving from the

source at the same moment without prior preparations for the chosen transport mode, that is:

- Researchers using bicycles and PC had to walk to their properly parked vehicles;
- The researcher who traveled by taxi should have called and waited for the arrival of the taxi;
- A researcher traveling by bus public transport should have walked to the nearest bus stop and waited for the bus.

Data collection during the research was carried out with the mobile application "GPS Logger", which recorded the time and exact passengers' location, i.e., latitude, longitude and altitude, using the Global Navigation Satellite System (GNSS). The researchers were trained in advance for application usage. The location parameters in the application are updated every second, that is, with a frequency of 1 Hz. The measurement error was ±7 m, which represents the standard deviation of a single-channel GNSS system without additional corrections.

3. RESULTS AND ANALYSIS

The comparative analysis of travel time for the researched transport modes was performed through the presentation of research results, namely: comparative analysis of movement speed by time, space-time diagram, comparative analysis of time components of travel, as well as the share of individual time components in the total travel time.

The movement route by transport mode was determined by the traffic infrastructure and arbitrary choice by the researcher. The shortest movement route was achieved by hiking and it is 4,272 m, and the longest movement route is achieved by PC and it is 5,239 m.

Movement dynamics of research participants differ by section and by transport mode (as on Figure 2). The user of Taxi transport was the first to reach the finish line, after 19.7 min. Immediately after, the cyclist and the PC driver arrived, who crossed the researched route in 20.8 min and 22.6 min observed respectively. So, the average travel speeds of bicycles, taxis and PC are close, with values of 13.1 km/h, 14.3 km/h and 13.9 km/h observed respectively (as on Table 1). The last to reach the destination was a pedestrian with a travel time of 41.4 min, with the lowest average speed of 6.2 km/h.

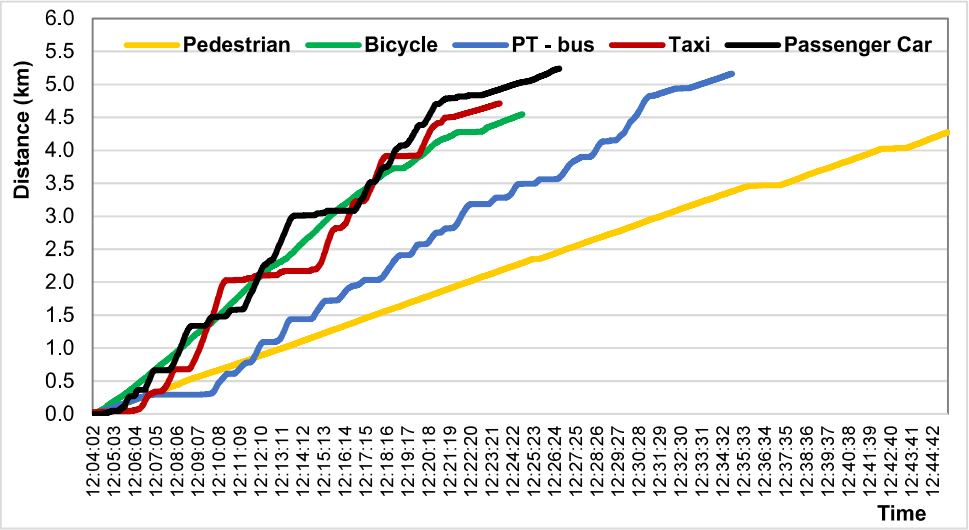

Figure 2. Spacetime diagram

Table 1. Time components, distance and speeds

Parameters	Pedestrian	Bicycle	PT-bus	Taxi	PC
Access time [min]		0.0	3.0	0.6	0.5
Waiting time [min]			4.6	1.7	
Running time* [min]	38.8	17.4	13.8	8.8	10.0
Dwell time-intersection [min]	2.6	1.7	4.2	6.6	8.3
Dwell time-station [min]			4.2		
Finish walk time [min]		1.8	3.2	2.2	3.8
TOTAL travel time [min]	**41.4**	**20.8**	**32.8**	**19.7**	**22.6**
TOTAL lost time [min]	2.6	1.7	13.0	8.2	8.3
Distance [km]	4.272	4.548	5.163	4.712	5.239
Avg speed [km/h]	6.2	13.1	9.4	14.3	13.9
Max speed [km/h]	8.9	20.9	47.1	65.3	50.6

* hiking time for pedestrian

* It also includes bicycle parking time and car parking time

The greatest constancy in movement was achieved by pedestrians and cyclists (as on Figure 3). While the longest one-time delay, while waiting at the bus stop (dwell time-bus stop), was a PT-bus passenger. This delay of passengers amounted to 4.8 min. The taxi transport user had the greatest unevenness in movement speed. In this transport mode, the highest speed of 65.3 km/h was recorded.

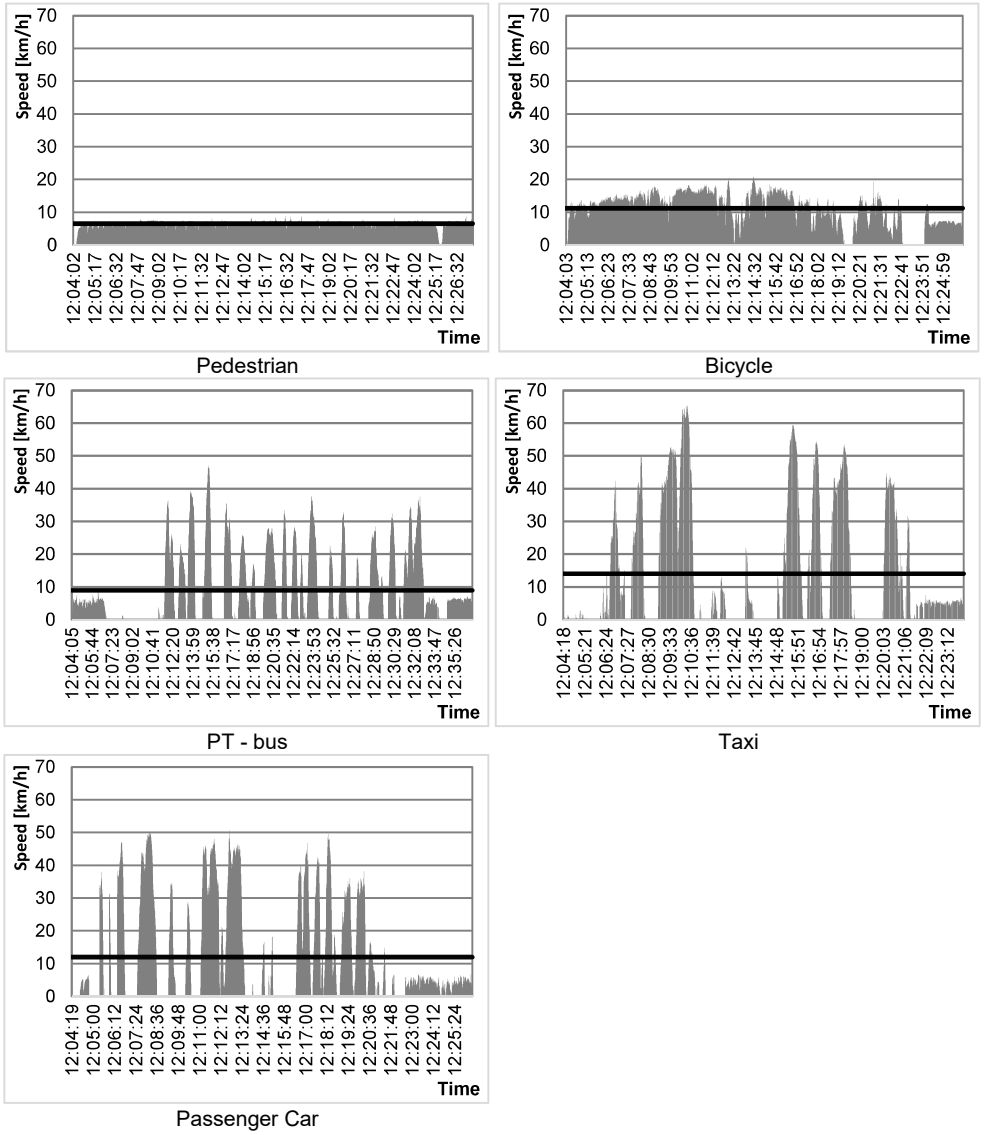

Figure 3. Comparative graph of speed by transport modes

In the case of motorized transport modes (PC, taxi, PT-bus) there is a significant difference between the median and mean speed values (as on Figure 4). A significantly lower median value than the mean shows that users of motorized transport modes spend a large part of their time at rest or moving at low speeds. This difference is created by traffic jams and delays at intersections, as well as the transportation availability in time. In Novi Sad, the transport availability in time is

particularly pronounced with the PT-bus, where passengers often wait longer than 10 minutes for the vehicle.

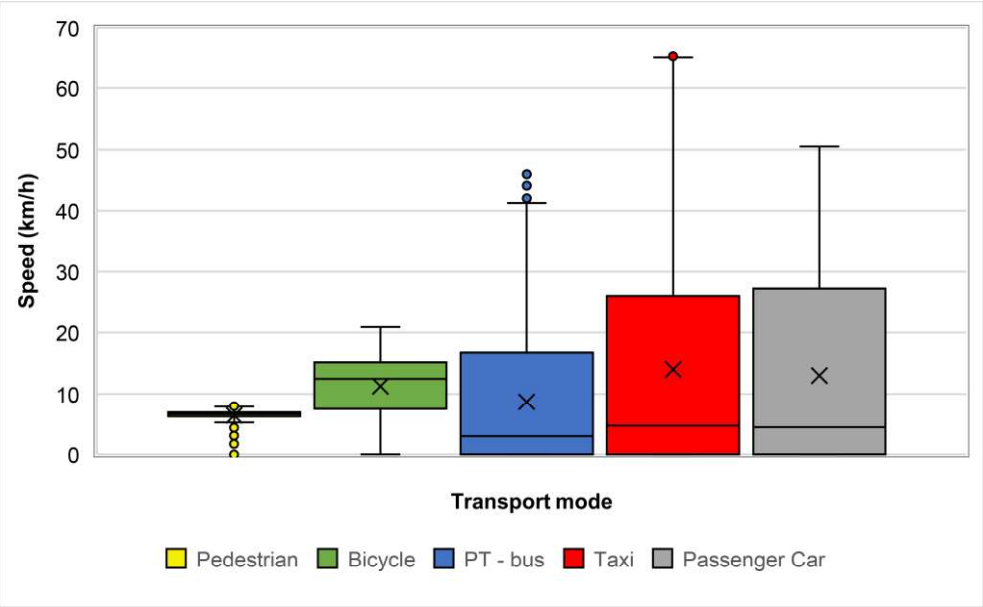

Figure 4. Box plot of speed by transport modes

The following graphic shows the structure of travel time for the researched transport modes. Special emphasis is placed on the time passengers spend in a state of rest, the so-called time losses. For this analysis, the time spent in a state of rest is significant because: it represents ineffective time that negatively affects travel time and average travel speed, mostly contributing to the unevenness of travel speed, it has a bad effect on the subjectivity of experienced travel time, etc.

Walking and cycling have the smallest share of time losses in the total travel time structure, less than 10% (as on Figure 5). Motorized transport modes account for a significantly larger share of time losses in the total travel time, amounting to around 40%. In the case of taxi and PC transport modes, the dominant time losses are waiting at intersections (dwell time- intersection), which amount to 6.6 minutes and 8.3 minutes, respectively. Compared to PC, taxi users have additional time lost waiting for a taxi (1.7 min), while PC drivers have to park their vehicle. In this research, no time losses were recorded during parking, but the parking location affected the longer walking time to the destination (3.8 min).

The structure of the time a PT-bus passenger spends at rest is significantly more complex compared to the other researched transportation modes. First of all, there is the time that the passenger spends waiting for the vehicle at the bus stop, which amounted to 4.6 minutes, or 13.96% of the total travel time. Then, while the passenger is in the vehicle, there are time losses, namely: dwell time at intersections and dwell time at bus stops to change passengers. Within the scope of this research,

both of these times were 4.2 min each, or 12.96% of the total travel time. So that the PT-bus user spent 13.0 min in idle mode, which represents 39.44% of the travel time.

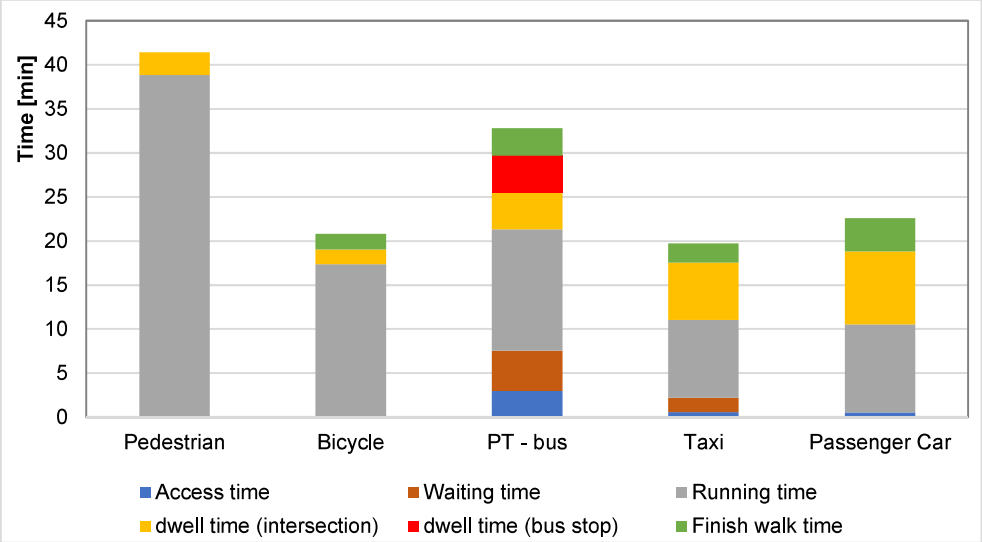

Figure 5. The structure of travel time by transport modes

4. CONCLUDING CONSIDERATIONS

Given the favorable climatic and relief characteristics of the city, the bicycle is one of the promising alternative transportation modes in Novi Sad. Based on the research, it can be concluded that if there is adequate infrastructure in Novi Sad for the chosen travel route, the bicycle is an alternative to the car, which in terms of travel time is competitive with all other transport modes.

Considering that non-motorized modes (e.g. walking and bicycle) are alternatives usually restricted to short-distance trips [9], public transport can effectively competes with passenger car for medium to long-distance trips.

In order to make the choice of public transport more attractive than the car, a high level of public transport service [10] and the high car costs are necessary [11].

The travel time structure of PT-bus users is significantly more complex compared to the other transport modes, which creates additional uncertainty in the passenger travel time. As a rule, passengers solve the problem of uncertainty by incorporating a protective time into the planned travel time and they start earlier in order to safely reach their destination on time.

According to this modest research, PT-bus travel in Novi Sad takes significantly longer time compared to other motorized transport modes. Passenger transport can be characterized as the slowest transport mode in Novi Sad because of the time losses, that is, the time the passenger spends in a state of rest during the journey.

There are three basic time components that have a negative impact on the length of the passenger's journey, namely: waiting for the vehicle arrival, dwell time at intersection at intersections, and dwell time at bus stops to change passengers. Reducing time losses within all three components of travel time is key to solving the inferior position of PT-bus in relation to other transport modes in Novi Sad.

In the following period, it is planned to repeat the research on a large number of routes in Novi Sad in order to obtain statistically valid results, as well as the development of a model for determining the dynamic elements of the lines that would provide a competitive service to the car.

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