Public Transport Priority System: Impact on Quality of Service

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Abstract. *This paper is based on ongoing research, within CiViTAS ELAN project (co-funded by the EU), about the implementation of public transport (PT) priority system in Zagreb. Prioritising the PT vehicles at signalized intersections has proven to be an effective way to increase the Quality of Service (QoS) for the PT users in terms of reducing travel times between PT stops. In this paper the evaluation methodology applied for the purpose of detecting the impact of PT priority system on the PT QoS is elaborated. We define a set of evaluation indicators which are used for the decomposition of PT vehicle operation time into different segments. The operation time decomposition enables the identification of different background data impacts on the PT system performances. In addition, different data collection methods are described and evaluated: manual time recording, GPS (Global Positioning System) vehicle tracking, PDA computer system and manual video data processing. Each method is set against several criteria and comparative analysis is carried out.*

Keywords. PT priority system, quality of service, evaluation, data collection methods

1 Introduction

In 2008, the City of Zagreb together with other partners accepted the participation in the collaborative CiViTAS ELAN project, co-funded by the European Union. Project activities are divided into several work packages and each of them consists of several thematically linked measures. Every measure has its own objectives. One of the measures which is going to be implemented in the City of Zagreb is to introduce (demonstrate) the public transport priority system at signalized intersections, [1]. There are two main objectives of this measure:

- To increase the average speed of public transport vehicles (tramways) by giving them priority at intersections,
- To reach improved mobility for all vehicles in the city by creating a system of coordinated traffic lights and „intelligent crossings".

In order to define the impact of the priority system on the overall PT QoS (Public Transport Quality of Service) usually a cost and benefit analysis is applied, [2], [3], [4] and [5]. By conducting the evaluation of PT system performances using just this abovementioned method, certain transport impacts can easily be omitted. Furthermore, other impacts which could have an influence on evaluation results are often neglected; therefore, the results are compromised.

This represents a problem because other CiViTAS ELAN objectives (reducing the number of cars in the city centre, increasing the number of PT users, promoting sustainable mobility solutions, etc.) will produce different background impact which could influence on PT priority system performance. Therefore, simple recording and monetising the value of user travel times, vehicle round trip times and detection of changes of average vehicle speed cannot point out other background impacts which could cancel out the positive effects of PT priority system. In order to identify the background data impact and to preserve validity of the evaluation results, PT vehicle operation time decomposition has been introduced.

Different data collection methods for the abovementioned evaluation analysis are applied:

- Manual time recording
- GPS (Global Positioning System) vehicle tracking
- PDA computer system
- Manual video data processing.

Each of those methods is evaluated according to the several criteria and a comparative analysis is carried out.

2 Defining evaluation methodology

2.1 Identifying background impacts

By analyzing the PT network in the City of Zagreb, specifically tramway infrastructure, it can be seen that, on the most tramway lines, infrastructure is shared with other transport modes (mostly with individual transport). In the peek and off peak periods of the day, when transport demand is on highest levels, queues of cars are forming in front of signalized intersections, often blocking the tramway pathway. The number of cars on the roads depends on wide variety of factors: transport costs, availability of other transport modes and interconnectivity between them, economic situation, etc.

Several measures of the CiViTAS ELAN project are devoted to the promotion of PT system services. The main objective of those measures is to increase the number of patrons and contribute to the sustainable urban transport system. More patrons could require more PT vehicles in order to satisfy the transport demand. Presumably, with more PT users it will also take longer for people to get on/off at the PT stops. This means that PT vehicles will spend more time on the PT stops, thus their round trip times will be increased.

All of the above is detected as a background impact on the PT QoS. In the analysis of possible benefits of PT priority system, this kind of impacts mustn't be ignored. A new evaluation approach is needed in order to evaluate the real impact of such system.

2.2 Operation time decomposition

By the term *operation time* we consider the time that elapses from the departure of a PT vehicle from one terminal until the arrival on the other terminal on the same line. One public transport line (tramway line) has two terminals and finite number of PT stops in-between.

If we look at the Fig. 1 we can detect possible events which can occur during one PT vehicle journey from one terminal to another.

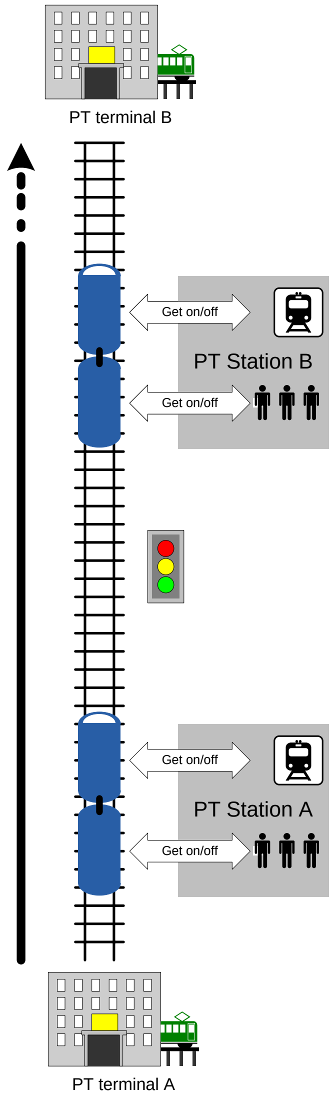

Figure 1: Possible events on tramway itinerary

Knowing the background impact described in the previous chapter it is evident that PT vehicle operation time is highly influenced by those impacts. For instance, even if the tramway gets the absolute priority at every signalised intersection between Terminal A and Terminal B, that gain of time can be easily cancelled out because of increase of time needed for patrons to get on/off vehicle.

In order to tackle this problem and to preserve validity of evaluation results the vehicle operation time decomposition is applied, as it is depicted in the Fig 2.

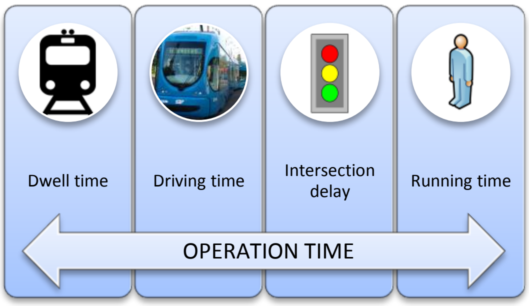

Figure 2: Operation time decomposition

By doing this, vehicle operation time is consisted out of four evaluation indicators. Additionally, commercial speed and speed per segment are also included as important QoS indicators. The list of all QoS indicators is presented in the Table 1.

Table 1: QoS indicator description

INDICATOR	DESCRIPTION
Operation time	The time that elapses from the departure of a tramway from a terminal to the arrival at the other terminal on the line.
Running time	The time that elapses from the departure of a tramway from a stop to the arrival of a tramway at the adjacent stop. *Note that this indicator can also be related with user perception about his/hers travel time between adjacent PT stops.
Intersection delay	The time that elapses from the arrival of a tramway at an intersection approach to its passing through the intersection.
Dwell time	The time which a vehicle spends on PT stops.
Driving time	The time that a vehicle spends in motion.
Speed per segment	Vehicle speed for predefined segments of the line.
Commercial speed	The average journey speed of public transport vehicles between an origin and a destination terminal, including any delay arisen in the course of the journey, [6].

As depicted on the Fig. 3, using this approach the tramway operational time is decomposed into different segments in relation to the possible events in the itinerary.

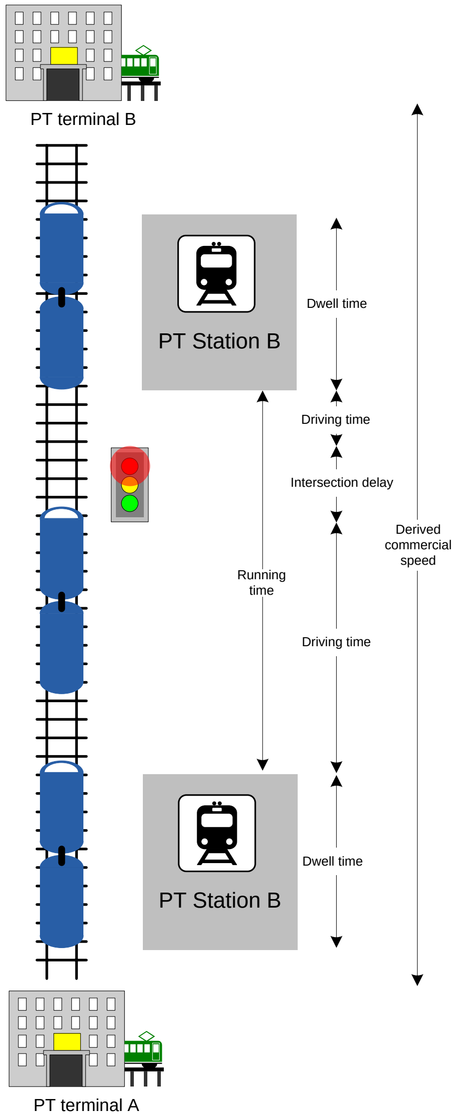

Figure 3: Segments of operation time in relation to the possible events in the tramway itinerary

After the introduction of a PT priority system the key improvement is expected in the decrease of intersection delay and running time. With the data collection for the abovementioned indicators and knowing the distances, a commercial vehicle speed can easily be calculated, even for different segments if so desired. Furthermore, critical points in the network in which PT system performances deteriorate can be identified.

Without this information evaluation results wouldn't be representative. It would be impossible to determine the real impact if only operation time would be measured and evaluated.

3 Data collection methods

In order to collect the data about the operation time and its segments, four data collection methods were applied:

1. Manual time recording
   - Six students equipped with stop watches traveled in tramways in the time period of one week and manually recorded the time at control points (PT stops and signalized intersections).
   - Data was manually imported into a computer.
   - During data processing, the before mentioned indicators were derived.
2. GPS (Global Positioning System) vehicle tracking
   - Four GPS receivers were installed in four tramways traveling on the same line.
   - Recording took place in one week period (Monday to Sunday), each day from 6 AM to 10 PM.
   - Every device recorded the vehicle position and actual speed with one second step.
   - GPS data was extracted from the devices and imported in an Excel table.
   - During data processing, the before mentioned indicators were derived.
3. Manual video data processing
   - The video track was extracted from vehicle surveillance system (for one working day).
   - While observing the recorded video, two students manually entered the data for performance indicators directly in Excel sheets.
4. PDA computer system
   - By using the application[1] installed on a PDA device one student recorded arrival/departure times on PT stop and on intersection, as well as duration of the dwell times.
   - The application recorded and calculated the QoS indicators in the data base.

[1] The application (TRAM FPZ) has been developed in the Visual Studio programming environment, using C# programming language, by Darko Jurišić (graduating student of Faculty of Transport and Traffic Sciences, Zagreb).

4 Evaluating data collection methods

While experimenting with different data collection approaches some advantages and disadvantages of previously mentioned methods were detected. This experience serves as a good basis for initial evaluation of data collection methods. For this purpose a set of criteria has been developed:

- Accuracy of the measurement
- Resolution of the measurement
- Method reliability
- Data processing
- Method execution:
  - Preparation
  - Human resources
  - Duration
  - Equipment cost
  - Simplicity.

Accuracy of measurement has been assessed based on the analysis of collected data and results. For instance, while applying manual time recording method, errors in the running time and intersection delay occurred. Depending on each individual student, that is, their perception, errors were in a range of 5 to 10 seconds. PDA computer system reduces that error to about 1 to 2 seconds. While applying the GPS vehicle tracking method the source of the error is the presence of a mismatch between geographical locations of the PT stations or signalized intersections and actual vehicle position. This error has special significance if it is occurring at the control points, when the vehicle speed is 0 km/h.

Resolution of the measurement means the frequency of data input (e.g. GPS vehicle tracking method has the best resolution because vehicle position is recorded in one second step, thus data is collected for the whole line, instead of just at the control points).

The method reliability criterion refers to the data and results representativeness. For example, while applying manual time recording method sometimes students did not record the exact date and time when the measurement took place. Furthermore, after the data processing it was detected that a few derived speeds per segment of the tramway line are simply faulty.

It can be easily concluded that for some of the applied methods data processing is the main downside (e.g. manual time recording method and GPS vehicle tracking) and for others it is just the matter of downloading the data into computer (PDA computer system). We evaluate this aspect with data processing criterion.

With the method execution criterion the intention is to point out the different aspects. A preparation sub criterion is associated with necessary activities which are needed to be undertaken before measurement. For instance, manual time recording includes organizing the students and designing the entry table layout, while GPS vehicle recording requires only device instalment. The number of people needed for execution of the measurement and data processing is evaluated with human resources sub criterion. Consequently, the time interval from preparation phase to the production of results is graded by duration sub criterion. Equipment cost refers to the approximate cost of the used equipment. Final sub criterion is introduced in order to evaluate the method simplicity.

The comparative method analysis was carried out. The results are shown in the Table 2 in a scale from 1 to 5 (1 meaning worst performance and 5 meaning excellent performance). We emphasize the fact that a complete and most accurate result of such analysis requires the application of each method in the same time and on the same tramway line. That was not the case in this research.

Table 2: Initial method evaluation

	Manual time recording	PDA computer system	GPS vehicle tracking	Manual video data processing
Accuracy	2	5	4	4
Resolution	3	3	5	4
Reliability	2	4	5	3
Data processing	2	5	1	2
Preparation	2	4	3	2
Human resources	2	3	5	4
Duration	2	5	2	3
Equipment cost	5	2	3	2
Simplicity	2	4	5	1
Average grade	2,5	3,75	3,625	2,625

As it can be seen from the Table 2 the manual recording method performed the worst (average grade). Slightly better method is manual video data processing method, but sill it has a large number of downsides which make it unattractive to use.

Initial method evaluation shows that PDA computer system method has performed very well, thanks to the TRAM FPZ application. The same grade would be applicable for the GPS vehicle tracking method, but first the data processing has to be improved.

5 Conclusion

After the analysis of possible background data impact which could interfere with the PT priority system performances, an operation time has been decomposed into different segments. The decomposition is based on possible events in the tramway itinerary (travelling between two PT terminals). This type of decomposition is needed because it enables the detection of all changes after the implementation of PT priority system on a very small scale (for a specific signalized intersection, if necessary). The data which is collected in this way enable very detailed analysis, covering data collection for majority of PT QoS parameters.

In order to select the optimal method for data collection, four data collection methods were applied and their performances were initially evaluated. For that purpose a set of criteria and sub criteria has been developed.

A new method which could perform excellent by all criterions, thus produce most accurate results, would have to be a combination of PDA computer system and GPS vehicle tracking methods, with necessary software support.

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