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The Impact of Unconditional Priority for Escorted Vehicles in Traffic Networks on Sustainable Urban Mobility

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Abstract: Efficient traffic systems control in large cities, and the complex traffic management of signalized intersections is a challenging task, particularly when dealing with high traffic volumes. The city of Zagreb faces this challenge, as all administrative and governmental institutions are in the historic part of the city, and routes for escorted vehicles have a significant impact on the traffic network. This paper addresses the issue of the impact of unconditional priority for escorted vehicles on the energy efficiency of the urban traffic network in the city of Zagreb. The traffic network model is developed using the PTV Vissim microsimulation software. The evaluation was conducted with nodes (delay, queue length, and number of stops) and network evaluation parameters (CO_2 emission, NO_x emission, PM_{10} emission, and fuel consumption). The results show that unconditional priority has minimal impact on energy consumption and exhaust emission in the observed scenario. This is a significant result considering all actions that must be undertaken to manage the passage of the escorted vehicles through the traffic network.

Keywords: signalized intersections; intelligent transport systems; adaptive traffic control; sustainable smart city concept

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1. Introduction

The improved concept of Intelligent Transport System (ITS) known as Cooperative ITS (C-ITS) represents a step towards the ideal smart city concept. This progression can significantly improve the urban traffic network's quality [1–5] with a proper implementation approach. C-ITS encompasses all functional areas of ITS [6], including traveler information systems, traffic control, incident management, and public transport management, serving as mandatory tools for optimizing traffic network efficiency and efficacy. The quality of an urban traffic network is directly connected with the overall quality of life in cities. In terms of energy efficiency and fuel consumption, projections by influential bodies, such as the International Energy Agency and the European Environment Agency, indicate that by 2050, traffic and transport will account for more than 50% of fuel usage, approximately 40% of CO_2 emissions, and over 70% of other exhaust gas emissions [7,8]. Also, it is possible to distinguish different causes of exhaust gas emissions. According to [9], nearly 22% of spent fuel is caused by excessive speeding, inefficient traffic control, ineffective and aggressive acceleration, and deceleration. As mentioned before, the C-ITS concept has the potential to enhance these parameters and address the underlying causes. One of the goals of the European eCoMove project [10] was to prove (in the simulation environment) that a reduction in CO_2 and NO_x emissions can be achieved only by respecting the optimum/recommended speed limitations [11]. An alternative towards the minimization of fuel consumption and exhaust gas emission involves the optimized routing of individual vehicles within urban traffic networks and the implementation of adaptive signal control at signalized intersections. These interventions have a direct impact on the frequency of stop-and-go actions and culminate in reduced average delays at signalized intersections [12–14]. Simulation software serves as a common and inevitable tool for assessing diverse approaches in traffic control and vehicle movement optimization within networks. Several studies have delineated the correlation between average travel times, fuel consumption, and simulation-based optimization techniques [14,15]. The advancements were made with q-learning algorithms, which presented improvements in CO_2 reduction and a reduction in the number of vehicles in queue lengths [16–18]. Considering the possibilities of the simulation of various traffic optimization methods, their impact was presented in several papers in which exhaust gas reduction was achieved with the implementation of k-means and LOESS (locally weighted scatterplot smoothing) algorithms [19], dynamic speed limit control algorithms [20], and adaptive transit priority strategies in urban areas [21]. It is possible to conclude that advanced traffic control strategies have an impact on exhaust gas emission reduction, specifically when a complete smart city concept is implemented, even though major infrastructure predispositions are necessary. At a lower level of implementation, it is possible to only observe one vehicle type (public transport vehicles, emergency vehicles, etc.) and give priority to that specific type of vehicle at signalized intersections.

Traffic signal control, as mentioned before, is a measure that can have the most influence on ecological aspects in urban areas (regarding exhaust gas emission, noise reduction, etc.) [22,23]. Traditional traffic signal control (i.e., fixed signal timing) methods are not sensitive to real-time traffic variations. They can be ineffective [24], so the adaptive (improved) control of signalized intersections in the context of giving priority to certain vehicle categories is suitable. Priority on signalized intersections includes providing a green light to certain vehicle categories whenever possible, with three main priority strategies [25]:

- Passive priority strategy;
- Active priority strategy;
- Unconditional priority.

Passive techniques entail predefined signal timings adapted to specific requirements (such as the frequency of green lights on particular approaches, adjusted green light duration based on adjacent intersections, and abbreviated cycle duration). Passive techniques do not need the presence of vehicles, nor the notification of their arrival at the intersection. On the contrary, active priority techniques are activated only upon vehicle presence or demand signaling. These techniques encompass green extension, early green (red truncation), and green phase insertion. Upon receiving a priority demand at the traffic management center, the system predicts the vehicle's arrival time at the signalized intersection [26]. Unconditional priority, or vehicle preemption, guarantees a designated vehicle right of way through the signalized intersection by interrupting regular signal timing irrespective of the active signal phase. Once the active phase ends, considering minimal safety green time, the green light for the approaching vehicle demanding unconditional priority is activated. While uncommon in public transport scenarios, unconditional priority finds widespread application for emergency vehicles; very important persons—VIPs; and other escorted vehicles. Passive and active priority strategies modify the existing signal timings, while unconditional priority interrupts these timings to prioritize the green light for the desired approach [23].

It can be observed that with the optimal selection of control strategy, it is possible to directly impact the energy consumption of vehicles in the urban traffic network, which can strengthen the general idea of sustainable traffic management in urban areas. Also, by acting on certain aspects of traffic management on a local and isolated level, it is possible to contribute to the sustainability of the transport system, but with a comprehensive approach, the visibility of the impact is much greater.

The literature overview and the present research in the field of traffic management with respect to the impact on energy consumption are presented in the Introduction, while the methodology and the connection of the presented idea with a specific vehicle class (escorted vehicles) are presented in the second chapter. In the third chapter, a case study regarding the modeling of unconditional priority in the city of Zagreb is presented, while the results and discussion with the presentation of future work are described in the succeeding chapters.

2. Model and Research Methodology

Following the identification of the research domain that acknowledges the potential for enhanced traffic control to significantly impact the energy efficiency and sustainability of urban traffic systems, delineating a specific problem for the research study is imperative. The focus of this study is on escorted vehicles, which influence the traffic flow via the application of unconditional priority strategies. Escorted vehicles, as defined by the Road Traffic Safety Act [27], refer to vehicles monitored by law enforcement agencies, and they are equipped with specialized sound and red/blue light signaling devices. These vehicles commonly accompany state officials and also foreign delegations among others. While the minimum number of vehicles forming an escorted queue is not specified, a queue, as per [27], implies the movement of at least three vehicles consecutively in the same direction. Notably, this research does not encompass vehicle-to-vehicle (V2V) cooperative communication, leaving it as potential groundwork for future exploration.

2.1. Simulation Model Development

The city of Zagreb, serving as the capital and the largest city of the Republic of Croatia with a population of 767,000 (according to the 2021 Census), houses all key governmental and administrative entities. Despite Zagreb's constant expansion, major administrative hubs remain situated in the city's northern historical district, while the airport and primary entries are located in the south. Within the scope of this study, Figure 1 illustrates the route used by the escorted vehicles to access Zagreb's historic district. Notably, St. Mark's Square, pinpointed on the map, hosts the Croatian Parliament and other administrative centers. After the collection of all traffic parameters on the selected route (number of vehicles, vehicle categorization, vehicle routing, etc.), critical signalized intersections were identified and selected for the implementation of priority algorithms, which are also presented in Figure 1.

Following the definition of a demonstration corridor with two signalized intersections for the implementation of unconditional priority, relevant traffic data were systematically gathered and analyzed. Specifically, the peak morning hour (8 AM–9 AM) was identified as the observed period for this research study in order to construct a robust simulation model within the PTV Vissim simulation software; physical attributes (number of lanes, lane width, signal lantern placements, etc.) were meticulously identified, measured, and seamlessly integrated into the simulation framework.

Figure 2 illustrates the physical infrastructure of the selected intersections, delineating the placement of signal heads/lanterns. While there are two distinct physical intersections, Figure 3 illustrates that both intersections are under the control of a single signal controller. Consequently, for the purpose of this study, they are treated as a unified demonstration intersection. In this sense, four approaches to the intersection can be defined:

- First northbound approach (NB1) governed by signal group V2;
- Second northbound approach (NB2) governed by signal group V9;
- Westbound approach (WB) governed by signal groups V1 and V8;
- Southbound approach (SB) governed by signal group V3.

On the designated demonstration intersection, five vehicle signal groups (V1, V2, V3, V8, and V9) and seven pedestrian signal groups (P4, P5, P6, P7, P10, P11, and P12) have been defined. These signal groups operate within two phases, as depicted in Figure 4.

The signal cycle is 85 s, with the inter-green matrix calculated and integrated into the fixed signal plan. Correspondingly, aligning with the signal plan and the defined phases (as depicted in Figures 3 and 4), alongside the primary approaches and gathered intersection-specific traffic data, four vehicle inputs have been established:

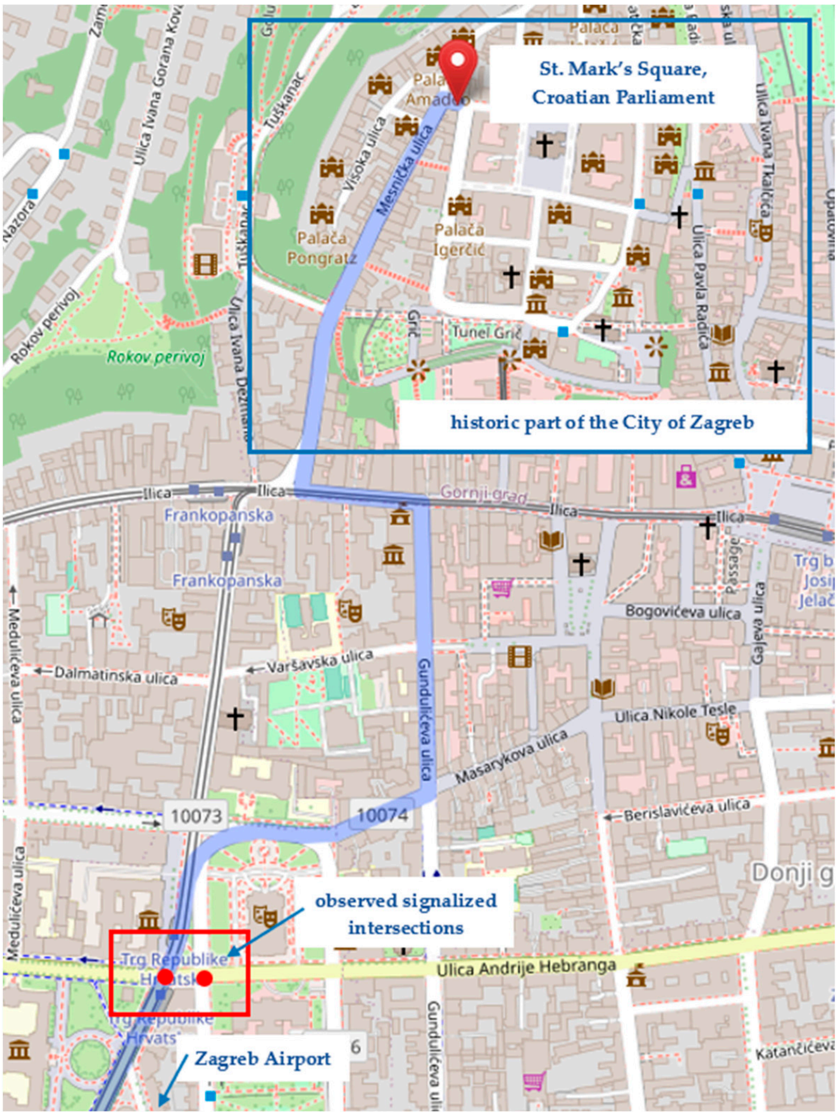

Figure 1. Graphical representation of the route of escorted vehicles with respect to selected signalized intersections.

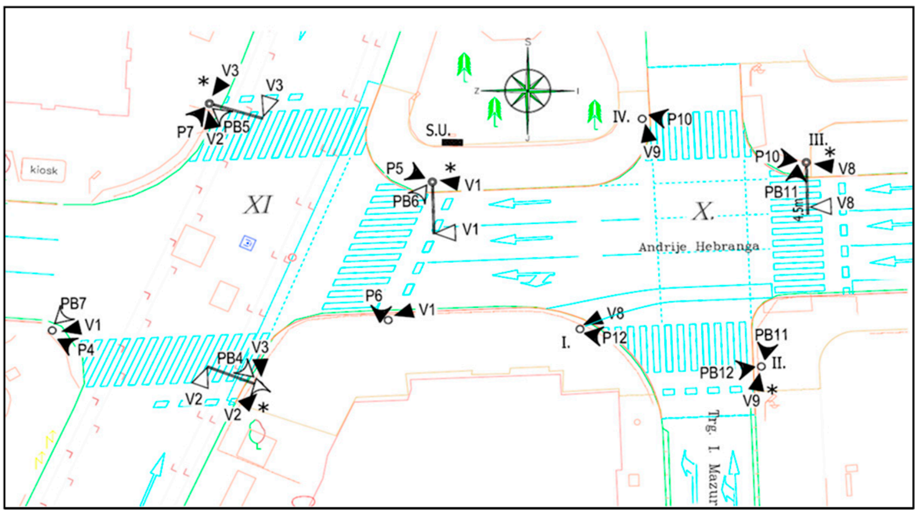

Figure 2. Physical components of the selected signalized intersections.

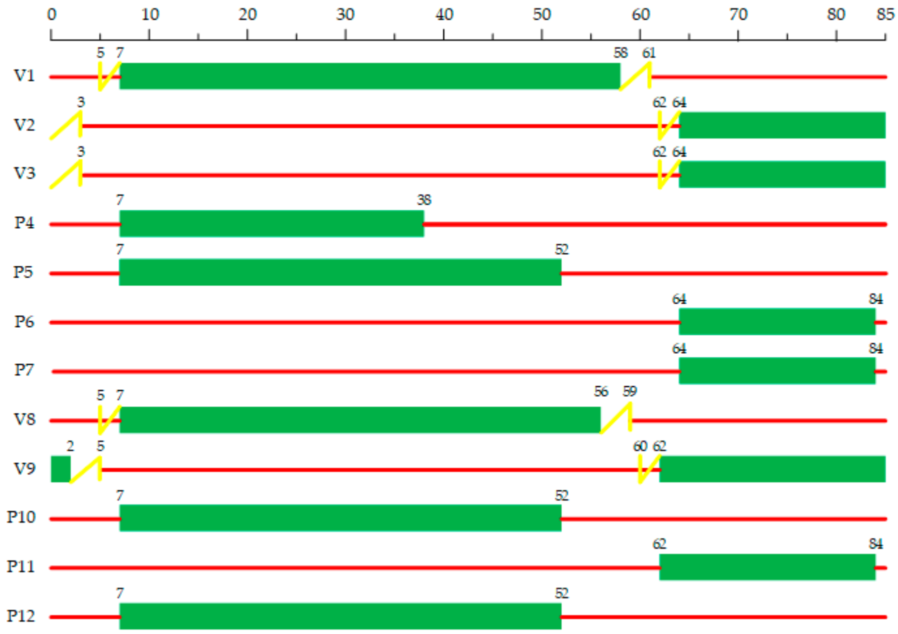

Figure 3. Signal timing of the selected demonstration intersection.

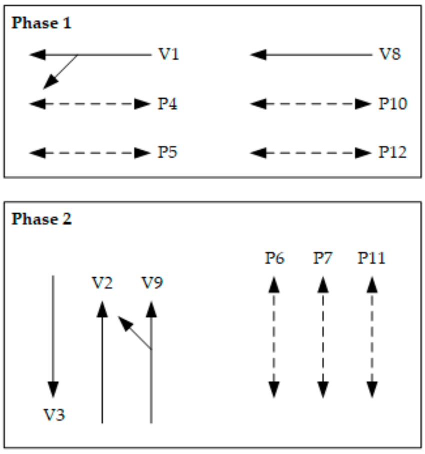

Figure 4. Defined phases and signal groups on the selected demonstration intersections.

- Input 1 on the NB1 approach—378 veh/h with 0.02 heavy-duty vehicles;
- Input 2 on the NB2 approach—262 veh/h with 0.05 heavy-duty vehicles;
- Input 3 on the WB approach—2029 veh/h with 0.01 heavy-duty vehicles;
- Input 4 on the SB approach—321 veh/h with 0.04 heavy-duty vehicles.

The collected data underwent calibration using *GEH* statistics [28]. The *GEH* statistic, named after its creator Geoffrey E. Havers, serves as a comparative formula for traffic volume evaluation, and it is defined by the following equation:

$$GEH = \sqrt{\frac{2(M-C)^2}{M+C}}, \quad (1)$$

where

M —hourly traffic from the simulation model;
C —real-world hourly traffic collected from the field.

GEH statistics facilitate comparison between two traffic volume sets: real-world volumes and simulation-derived volumes.

The duration of the simulation is 4500 s, with the initial 900 s allocated for model "warm-up" and the subsequent 3600 s dedicated for the simulation of the observed peak hour. The collected and calibrated traffic data are outlined in Table 1.

Table 1. Collected and calibrated input traffic data.

Approach on Intersection	Collected Data (veh/h)	Simulation Model Data (veh/h)	GEH
NB1 approach	378	360	0.94
NB2 approach	262	265	0.37
WB approach	2029	2189	3.44
SB approach	321	284	2.13
Total	2990	3098	1.98

According to [28], a calibrated model is identified if 85% of the overall traffic volume exhibits a GEH coefficient below 5.0. Also, if the GEH coefficient is above 10.0, the model is not calibrated, and the collected data and data produced in the simulation model are not relevant. The next step after the calibration of the model is the development of an unconditional priority algorithm for the selected signalized intersection. The development and implementation of the algorithm will be elaborated on in the following section.

2.2. Unconditional Priority Algorithm Development

The priority algorithm is developed for a two-phase signalized intersection scenario, anticipating the approach of an escorted vehicle platoon. When the first escorted vehicle is detected when approaching the intersection, the algorithm identifies the active phase, triggering one of two possible scenarios. The free approach (green light on its approach) for escorted vehicles is enabled by considering safety (minimum green) times during the opposite phase regardless of the traffic load at the intersection.

The development of unconditional priority algorithms is carried out within the PTV VisVAP module (visual vehicle actuated programming). This module enables the definition of adaptive program logic for signal controllers via flowcharts that articulate logical conditions. Simultaneously, a fixed signal plan is established in the PTV Vissim submodule to define signal logic elements (signal groups, cycle length, inter-green matrix, phase rotation, etc.). These elements are compiled into an ASCII file format (*.pua) that is utilized as input for formulating actuated unconditional priority algorithms [29,30]. The developed algorithm is checked for structural correctness and then exported into the (*.vap) file. Subsequently, both (*.pua) and (*.vap) files are integrated into the calibrated simulation model. This integration occurs via the driver file (vap216.dll), which is initiated based on pre-set parameters. Figure 5 presents a graphical depiction of this comprehensive process.

Limitation characteristics in the VisVAP approach arise due to the requirement of traversing the entire flow diagram within each simulation second. This constraint restricts the ability to halt at specific loops until pre-defined conditions are met.

Preceding the formulation of unconditional priority algorithms, it is imperative to establish the connection between the simulation model and the flow diagram (algorithm). Figure 6 illustrates the primary linkage achieved via detectors, specifically arrival (or login) detectors and logout detectors.

Detectors are positioned on the south approach of the monitored signalized intersection. Specifically, detector D1 functions to detect the presence (arrival) of the escorted vehicle platoon and has a login function to record the presence of escorted vehicles. Detector D2 is strategically positioned to identify the last point of the trailing escort vehicle. The distance between these detectors is 240 m, adhering to a minimum inter-green time of 15 s when assuming that the escorted vehicle platoon maintains a speed of 60 km/h. The escorted vehicle platoon, defined for this research study, comprises five vehicles with an average standstill distance of 4 m, resulting in a total distance of 37 m.

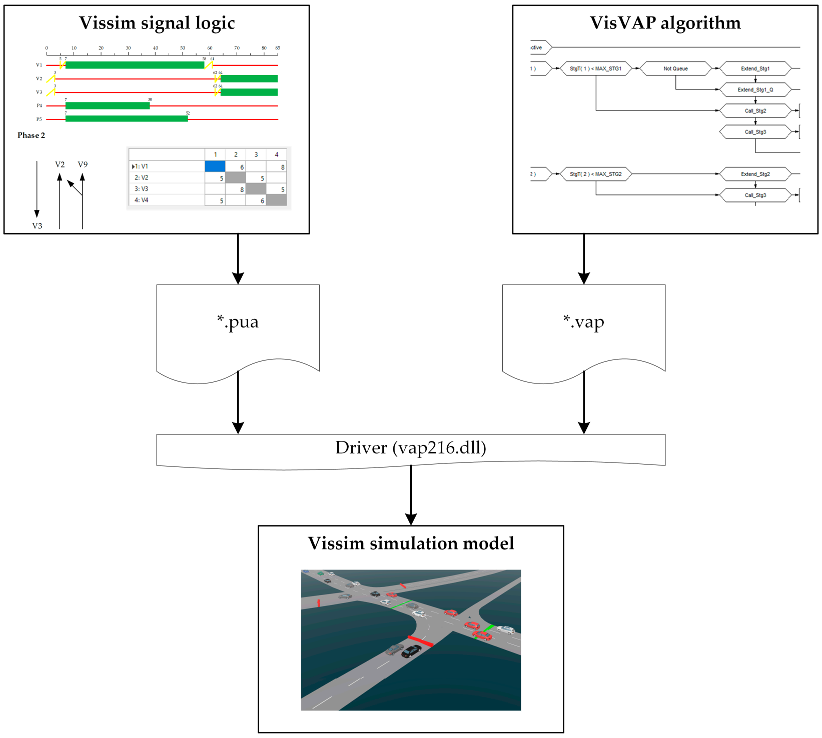

Figure 5. The graphical representation of the algorithm's integration.

Figure 6. Location of detectors for escorted vehicles in the simulation model.

The algorithm was developed for two situations: the active stage during the approach of the "VIP platoon" and the active conflict stage (WB approach). A simplified algorithm, developed in PTV VisVAP, is illustrated in Figure 7. The algorithm comprises three principal components: (1) cycle counter, (2) algorithm functions during the active NB approach phase, and (3) algorithm functions during the opposing (conflict) WB approach phase.

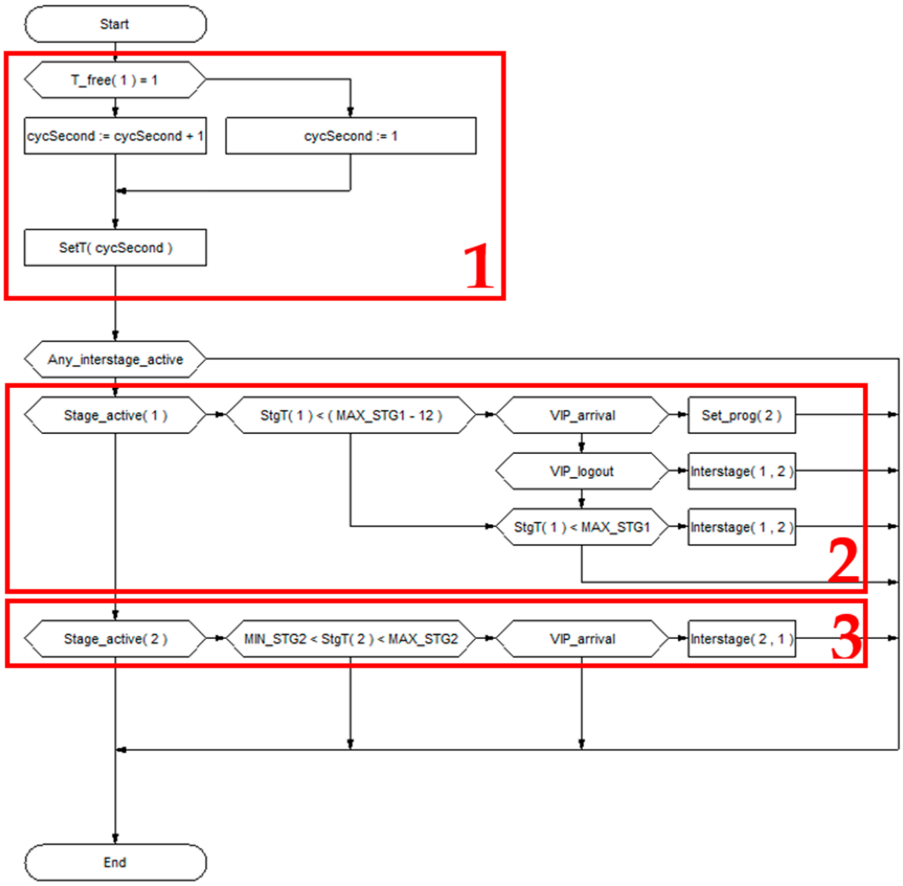

Figure 7. The algorithm structure for the unconditional priority of escorted vehicles using the PTV VisVAP module.

The initial segment of the algorithm involves a cycle counter where the variable cycSecond increments by 1 at every simulation step, utilizing the command SetT to store the updated value. When exporting fixed signal logic from Vissim, it is necessary to define the cycle's length, which is exported into the *.PUA file with other basic signal control information (number and definition of signal groups, types of signal groups, etc.). According to this information, the algorithm has to calculate and increase cycle seconds because the system checks the entire diagram from START to END in every simulation second. It must be noted that the phase change period (Any_interstage_active) must be intact, and nothing can affect that period.

During the active stage (STG) for the escorted vehicle platoon, identified by the variable Stage_active (1), the algorithm calculates the VIP platoon's arrival time at the intersection upon detection by the VIP arrival detector (VIP_arrival). An initial condition StgT (1) < MAX_STG1–12 assesses whether there is sufficient time for the escorted vehicle platoon to pass the intersection within the stage duration. If, within the last 12 s of the stage, the escorted vehicle platoon is detected, a green extension strategy is employed—extending the active stage by an additional 10 s Set_prog (2) to accommodate the VIP platoon's passage. The procedure for stage changes with the variable Interstage (1, 2) is activated upon the last vehicle's passage through the logout detector (VIP_logout).

The algorithm's third segment addresses the scenario when the opposing stage (identified by the Stage_active (2) variable) is active. It is necessary to provide free passage to the escorted vehicle platoon "as soon as possible" in order to provide unconditional priority, bearing in mind all safety elements regarding vehicles and pedestrians. Before the detection of the escorted vehicles, it is necessary to provide the minimum green time for vehicles on the WB approach so that the green truncation during the first period of the active phase is avoided. This was achieved via the first calculation condition of the active stage's duration with respect to variable/condition MIN_STG2 < StgT (2) < MAX_STG2. It must be noted that variable Stg stands for the green time of the selected stage/phase. After the minimum duration of the green time on the WB approach is fulfilled, the presence of an escorted vehicle platoon observed by the arrival (login) detector is examined with the condition VIP_arrival. Upon detecting the escorted vehicle platoon, the algorithm triggers the stage change procedure using the condition Interstage (1, 2). This calculation, under the presumption of the escorted vehicle platoon operating at a speed of 60 km/h, meticulously considers all pertinent safety parameters, encompassing pedestrian crossing times, inter-green matrices, and the related factors. In instances where no request for unconditional priority for escorted vehicles is registered, signal timing remains fixed, as stipulated in Figure 3.

3. Simulation Results

The subsequent step involved delineating parameters that are essential for evaluating the developed algorithm's impact on energy efficiency, network performance, and related metrics. Ten simulation runs were performed for each scenario—existing and priority model—with a duration of 4500 s and data collection interval of 3600 s after 900 s of network "warming up". The random seed value (which affects the stochastic functions in PTV Vissim and traffic flow) is set to 42, with a random seed increment of 1. For this research, the network performance parameters that directly impact the quality of the traffic network were used, together with exhaust gas emissions and fuel consumption. The defined evaluation parameters are delay, queue length (veh), the average number of stops, CO_2 emission (g), NO_x emission (g), PM_{10} emission (g), and fuel consumption (g).

After conducting simulations of existing and escorted vehicles' priority models, the evaluation data are collected. The base data that affect the network's performance and quality (delay, queue length, and number of stops) are gathered via node evaluation, and energy efficiency data are gathered via vehicle network performance evaluation. The traffic network quality indicators of the existing traffic situation and the unconditional priority model are presented in Tables 2 and 3, respectively.

Table 2. Average network performance indicators of the existing traffic situation.

Approach on Intersection	Average Delay (s/veh)	Weighted Average Delay (s/veh)	Queue Length (veh)	Number of Stops
NB1 approach	28.54	10,274.4	18.14	0.81
NB2 approach	22.17	5875.05	7.01	0.66
WB approach	4.75	10,397.75	21.50	0.21
SB approach	23.81	6762.04	9.22	0.71
Total average	10.75	33,309.24	13.96	0.59

Table 3. Average network performance indicators of the unconditional priority model.

Approach on Intersection	Average Delay (s/veh)	Weighted Average Delay (s/veh)	Queue Length (veh)	Number of Stops
NB1 approach	27.30	9828.00	17.29	0.79
NB2 approach	22.23	5890.95	7.03	0.67
WB approach	5.61	12,280.29	25.18	0.23
SB approach	23.02	6537.68	8.91	0.69
Total average	11.15	34,536.92	14.60	0.59

Network performance indicators were collected via node evaluation in PTV Vissim, which is used to determine specific data from the defined intersections. According to [29], there is no need for a manual section definition; thus, the data are collected for the defined node and selected vehicle classes. Node evaluation can determine the exhaust emissions, but the calculation is based on the emission data of the Oak Ridge National Laboratory (U.S. Department of Energy). Thus, because of the differences compared to European standards, energy efficiency data are collected and analyzed differently via vehicle network performance evaluation.

Vehicle network performance evaluation considers all vehicles that have already left the network or reached their destination and the vehicles that are still in the network at the end of the evaluation interval [31]. The vehicle's network performance evaluation is updated at every time step in the microscopic simulation. All values of exhaust emissions and fuel consumption are presented in grams (g) (see Table 4).

Table 4. Vehicle network performance evaluation of energy efficiency parameters (in grams (g)).

Model/Scenario	CO_2	NO_x	PM_{10}	Fuel Consumption
Existing	4,051,806	10,804,816	31,063,848	6,753,010
Priority	4,171,327	11,123,540	31,980,177	6,952,212

In addition to the mentioned parameters, the average speed of vehicles was also considered, which is an indicator that affects the energy efficiency and sustainability of the traffic network. The average speed for personal vehicles in the existing traffic situation is 2657 (km/h), while in the model with unconditional priority for escorted vehicles, the average speed is 25.82 (km/h).

4. Discussion

Many studies proved that traffic control and the better quality of the network have a direct impact on energy efficiency and the sustainability of traffic systems, especially in urban areas. According to the previous research carried out by the authors [9], where the overall benefit and the quality of traffic network management were influenced, the research in this paper includes the impact of unconditional priority on the emission of exhaust gases and fuel consumption in the city of Zagreb. Even though similar research was conducted regarding conditional priority relative to other vehicle categories (emergency vehicles, public transport vehicles, etc.), this is the first research study that observes escorted vehicles with respect to all their specific behavior in the traffic network. This concept of giving priority to the escorted vehicle platoon is applicable at every signalized intersection only with adjustments to the algorithm regardless of the traffic situation, volume at intersection approaches, number of phases, etc. This research was conducted with data collected from a real traffic situation and the development of an unconditional priority algorithm in the PTV VisVAP module. After determining the evaluation parameters, a simulation of the existing traffic network and situation with the implemented algorithm was carried out, based on which the relevant data presented in the previous chapter were collected. Evaluation parameters were divided into two groups: network evaluation parameters (node evaluation) and energy efficiency parameters (vehicle network performance).

Delay is the most common measure of the quality of an intersection, and it directly defines the level of service (LoS). Along with the queue length and the number of stops, it can define vehicle behavior in the network. In the simulation of the existing traffic situation, the delay was measured for every intersection approach, and an average delay of 10.75 (s/veh) was measured. In the simulation with the implemented unconditional priority algorithm, a delay of 11.15 s was measured, which is reflected in the deterioration of 3.56% of the average intersection delay, and the level of service is B. The next observed evaluation parameter is the queue length measured with respect to the number of vehicles. In the existing model simulation, an average of 13.96 vehicles were in the queue (in all approaches), while in the priority simulation, it was increased to 14.60 vehicles, which comprised an increase of 4.38%. The last observed parameter was the number of stops, which remained the same but had a minor reduction with respect to the approach where escorted vehicles operate, and the average number of stops (because of the unconditional priority algorithm) was reduced by 2.47%. It must be noted that the observed scenario changes with respect to network performance were minimal and in favor of the approach in which the escorted platoon of vehicles operates.

Regarding energy efficiency indicators, all defined parameters show an increase after the implementation of the unconditional priority algorithm. With the implemented algorithm for unconditional priority, the emission of CO_2 gas was increased by 119.52 g, NO_x increased by 318.72 g, the emission of PM_{10} increased by 916.33 g, and fuel consumption increased by 199.20 g. The measured energy efficiency parameters are increased overall by an average of 2.8%. Also, the relation of exhaust gas emissions with respect to the average delay can be noticed. Proportionally, with an increase in average delay, exhaust gas emissions increased. The average operating speed of vehicles is slightly reduced from 26.57 km/h to 25.82 km/h, which comprises a change of 2.82%. This enables the possibility of extending the proposed priority algorithms as a basis for the optimization of signalized intersections, with priority assignment given to escorted vehicles. This can be carried out using a directed objective function aimed at reducing stop-and-go actions and with the ability to carry out economical and harmonized traffic flow.

It must be noted that in this use case, unconditional priority has minimal impact on the traffic network, but this is mostly because only one passage of the escorted vehicle platoon is considered in a one-hour simulation. The study aimed to execute a "proof-of-concept" of unconditional priority at a critical real-world signalized intersection, leveraging real traffic data and signal timings. This transition promises a shift from the existing ad hoc management to a systematic and controlled approach where unconditional priority should only affect conflict phases but will minimize the delays of individual vehicles traveling in the same phase as the escorted vehicles platoon. Also, the specifics of the selected signalized intersection (major disproportion of traffic volumes on the east "green wave" approach to the escorted platoon approach) affect the slight increase in the measured evaluation parameters. The current practice is that the priority passage of the escorted vehicles is realized by placing police officers at the intersection, and they regulate traffic based on a radio report of the arrival of a vehicle at the intersection. The preparation of the passage through the intersection takes place for at least 10–15 min, which includes approximately 11 signal cycles with a flashing yellow signal and police officer regulation, which has a high impact on energy efficiency and fuel consumption within the traffic network. However, with the proper implementation and integration of unconditional priority for escorted vehicles across the entire route, there exists the potential to bypass additional safety and security protocols. This integration aims to minimize the impact of VIP platoons traversing the traffic network. Considering the above, situations regarding fuel consumption, exhaust gas emissions, and other evaluation parameters related to these specific circumstances were not considered in this research study, and these factors would greatly influence the research results, which provide the basis for future research. Also, this research study was conducted with respect to two signalized intersections on the only route for escorted vehicles to travel to the administrative part of the city of Zagreb from the direction of the city airport. For the implementation in a real-world situation, a prerequisite is a well-developed infrastructure that includes signal controllers of the latest generation, installed cameras with the function of vehicle detection, implemented communication infrastructure, and finally, a fully functioning traffic control and management center. This research study paves the way for improved traffic management concepts where specific vehicle categories (public transport vehicles, emergency vehicles, etc.) can have different roles and importance in the traffic network. By demonstrating the potential of unconditional priority algorithms for escorted vehicles, practitioners can visualize a structured and systematic approach to managing traffic, particularly at critical intersections. This new view holds promise for enhancing transportation efficiency, reducing operational delays, and curbing environmental impact by promoting smoother vehicular movement and reduced idling time and driver stress.

5. Conclusions

This paper considers the importance of managing escorted vehicle platoons passing through signalized intersections in urban traffic networks with the impact on energy consumption and exhaust gas emissions. The basic idea was to develop an algorithm for unconditional priority with the main purpose of replacing a large number of police officers managing traffic before and during the passage of escorted vehicles. The realistic traffic scenario based on the use case in the city of Zagreb, Croatia, was taken into account, and the most frequently used route for the passage to the district with government and other administrative destinations in the historic part of the city. After the collection of data and definition of evaluation parameters, the calibrated model of the existing situation and the new model with unconditional priority were developed and compared. The morning peak hour was selected as relevant for the evaluation of the specific situation of the signalized intersection. A slight increase in the defined evaluation parameters was recognized (given the specifics of the observed situation), but some details must be considered in future research. The general practice is that the preparation of the passage of escorted vehicles takes at least 15 min, which greatly affects the traffic flow and delays on intersections. Also, in this research, only one hour of simulation with one VIP passage through the intersection has been considered, with the discrepancy of traffic volumes on the side approaches. Bearing all this in mind, it is possible to positively impact the fuel consumption and emission of gases, which will be the subject of future research with the development of advanced priority algorithms for the entire route/network. Also, future work will be focused on the different use cases in urban environments with the upgraded algorithm for the generalized application in different traffic situations.

The extent of this research is just a minor part of traffic management and its impact on the quality of traffic networks. Together with adaptive traffic control, parking management, incident management systems, and public transport management, significant advantages and improvements can be achieved towards a smart and sustainable urban traffic network.

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