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Editorial

New Perspectives and Challenges in Traffic and Transportation Engineering Supporting Energy Saving in Smart Cities—A Multidisciplinary Approach to a Global Problem

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1. Introduction

Transportation, like other spheres of human activity, is constantly changing due to economic development. People are constantly improving the ways of moving using various energy sources, expanding infrastructures, and adapting cities to increasing traffic volumes. An efficient, modern, and demand-driven transportation infrastructure is the strength of a growing economy. The development of transportation improves the accessibility of regions and labor markets and reduces the nuisance caused by congestion. All these elements translate into economic benefits, competitiveness, increased productivity of enterprises and regions, as well as social benefits. However, transport consumes enormous energy resources; hence, all solutions in the scope of improving transportation infrastructure, vehicle construction, as well as modeling users' and drivers' behavior may constitute an element contributing to broadly saving energy.

This Special Issue will consist of papers describing the state-of-the-art in methods and solutions in traffic and transportation engineering supporting energy saving in smart cities as well as outlining trends already under way and future developments in this sector. Topics of interest include but are not limited to the following:

- Road traffic measurements, data analyzing;
- Road traffic (micro-, meso-, macro) modelling, simulation models;
- Road and intersection capacity;
- Optimization, route choice;
- Human factor in road traffic and transportation engineering;
- Road safety;
- Pedestrian and bicycle traffic and infrastructure;
- Public transportation solutions, parking;
- Contemporary problems of road traffic engineering and sustainable transportation;
- Intelligent transportation systems (ITS), traffic control and management;
- Smart grid services;
- Electric mobility;
- Environmental impacts of transportation systems;
- Life cycle analysis (LCA) of alternative energy vectors for road vehicles;
- Transportation systems and process modeling;
- Sustainable transportation development;
- Life cycle impact, fuel consumption, and emissions.

In the next section, we provide a brief review of the papers published in this Special Issue. These papers are included in the previously outlined thematic areas.

2. The Review of the Contributions in This Special Issue

This Special Issue presents original research and review articles addressing all aspects related to new perspectives and challenges in traffic and transportation engineering supporting energy saving in smart cities. Many of them are characterized by a multidisciplinary approach to a global problem. This collection spans a body of research papers that represents the efforts of 16 research papers.

H. Vasiutina et al. [1] examined the environmental impact of using cargo bikes in cities. It is a comprehensive review of existing approaches. The impact of the use of cargo bicycles for delivery processes on the environment is undeniably positive: it leads to a reduction in pollutant emissions, noise, and vibrations caused by traditional vehicles; decreases traffic jams; causes more effective use of public space; and others. But how should such an effect be measured? What tools should be used to justify the necessity for change to more sustainable means of transportation? How can we improve the state of the environment considering the interests of logistics service providers? There is a large amount of scientific literature dedicated to this problem: by using different modeling approaches, authors attempt to address the issue of sustainable transportation. This paper conducted a literature review in the field of green cargo deliveries, investigated the benefits and drawbacks of integrating cargo bikes in urban logistics schemes, and examined methodologies and techniques for evaluating the impact of using cargo bicycles on the environment. By providing an opportunity to become acquainted with the situation in the sphere of green deliveries, the authors aimed to encourage a breakthrough in the field of sustainable transportation that may be achieved by using cargo bikes in modern cities. The authors present a review of the existing approaches and tools for modeling transportation emissions and state the significant positive environmental consequences. The main approaches were the estimation of emissions based on analytical models, including the following: traffic performance characteristics and emissions using an integrated model consisting of the Transport Systems Modeling software (TSM); emissions and dispersion using an integrated model consisting of TSM software; simplified air pollution using an integrated model consisting of TSM software; and vehicle emission computation using an integrated model consisted from traffic emission and dispersion. Moreover, as the main tools used to the estimation of the environmental impact of transport, they indicated analytical models, ArcGIS Visual Basic and Moves, Mainsim Scipuf and CyberGIS, FlexSim and regression models, Paramics MS Access and IVE, and Emisens.

In the next paper, prepared by A. Sołowczuk, and D. Kacprzak [2], the problem of the identification of determinants of the effectiveness of on-road chicanes in transition zones to villages subject to a 70 km/h speed limit have been presented. In recent decades, traffic calming, especially in villages characterized by relevant through traffic, has become an urgent issue. Various schemes are applied in the transition zones to reduce the inbound traffic speeds and thus improve traffic safety. The studies conducted in several countries point to different determinants of the speed reduction obtained in this way. This article dealt with schemes including a central island horizontally deflecting one lane located in transition zones to villages with 70 km/h speed restriction on two-lane roads (6 m carriageway width). To identify the speed reduction determinants, the speeds before and after chicanes were measured, and the effects of the three criteria were investigated, characterizing the traffic management scheme, road design parameters, landscape elements present in the surroundings of the transition zone, and visibility conditions. Based on the confirmation of the logical tautology of many pre-selected factors, one aggregate parameter was proposed for the assessment of the practicable level of speed reduction, combining the effect of the selected factors in the above-mentioned criteria. Statistical analysis of the obtained results confirmed a statistically significant relationship between both the speed reduction value, the speed reduction index, and the aggregate parameter proposed by

the authors. Factors related to the surrounding landscape and visibility conditions were found to have the greatest direct effect on speed reduction. The chicanes chosen in the final step of the proposed design process should be enhanced by additional solar-powered elements, ensuring their improved visibility. These devices should not, however, require any additional energy supply and should not increase the construction or maintenance costs. The further development of this topic has been included in the works [3–5].

The main purpose of the study [3] was to identify the speed reduction determinants in traffic calming schemes in village transition zones based on a central island horizontally deflecting one lane of a two-lane, two-way road with a 50 km/h speed restriction. As part of the study, vehicle speeds were measured just before and after the chicanes under analysis. Furthermore, the inbound lane traffic volumes were measured in field, and a number of factors were identified, including the applied traffic management scheme, road parameters, view of the road ahead and of the village skyline, isolated buildings, road infrastructure, and adjacent roadside developments. The obtained data were analyzed with a method employing the tautologies of the 32 selected factors affecting the drivers' perception. A single aggregate parameter was proposed for assessing the coincidence of the influence of selected factors on speed reduction. The analysis of the existing schemes and the results of statistical analyses carried out in this study confirmed the authors' hypothesis that the combined selected factors produce a desirable effect and that they should be additionally enhanced by the application of solar-powered devices.

The purpose of the study [4] was to investigate whether the applied traffic-calming measures had a considerable bearing on the reduction in speed to the desired level, as assumed in the traffic-calming plan. Three street sections starting and ending with different intersection types were chosen to examine the synergy of the applied traffic calming measures. The numbers and speeds of vehicles were measured in three-day-long continuous surveys. As expected, the amount of speed reduction depended on the hourly traffic volume on a one-way street and various other traffic engineering aspects. The obtained results may be used to modify the existing speed profile models and can guide traffic engineers in choosing the most effective traffic calming measures.

Meanwhile, in [5], the authors put forward a hypothesis of there being some determinants which, in combination, influence speed reduction in village transition zones. To corroborate their hypothesis on the combined impact of the transition zone features on speed reduction and in order to validate the established relationships, the authors conducted a verification study in transition zones containing chicanes or central islands. The Authors studied twenty transition zones and managed to confirm the hypothesis at a 95% confidence level. The contribution of this study is a further investigation of the synergy effect of various relevant factors, and the findings can assist in planning new transition zones or suggest additional measures to achieve the desired speed reduction in existing transition zones.

In turn, O. Pietrzak and K. Pietrzak [6] presented the economic effects of electromobility in Sustainable Urban Public Transportation. This paper focused on the effects of implementing zero-emission buses in public transportation fleets in urban areas in the context of electromobility assumptions. It filled the literature gap in the area of research on the impact of the energy mix of a given country on the issues raised in this article. The main purpose of this paper was to identify and analyze the economic effects of implementing zero-emission buses in public transportation in cities. The research area was the city of Szczecin, Poland. The research study was completed using the following research methods: a literature review, a document analysis (legal acts and internal documents), a case study, a ratio analysis, and a comparative analysis of the selected variants (investment variant and base variant). The conducted research study has shown that economic benefits resulting from implementing zero-emission buses in an urban transportation fleet are limited by the current energy mix structure of the given country. An unfavorable energy mix may lead to increased emissions of sulfur dioxide (SO_2) and carbon dioxide (CO_2) resulting from the operation of this vehicle mode. Therefore, achieving full effects in the field of electromobil-

ity in the given country depends on taking concurrent actions to diversify the sources of power generation and on increasing the share of Renewable Energy Sources (RES).

Furthermore, in the paper [7], a new back-of-queue model of a signal-controlled intersection approach development based on an analysis of vehicle driver behavior has been presented. In smart cities, it is expected that transportation, communication, as well as the movement of people and goods will take place in the shortest possible time while maintaining a high level of safety. In recent years, due to the significant increase in the number of passengers and vehicles on the road and the capacity limitations of transportation networks, it has become necessary to use innovative technologies for intelligent control and traffic management. Intelligent transportation systems use advanced technologies in the field of data gathering, information processing, and traffic control to meet current transportation needs. To be able to effectively control and manage road traffic, it is essential to have reliable mathematical models that allow for a faithful representation of the real traffic conditions. Models of this type are usually the basis of complex algorithms used in practice in road traffic control. The application of appropriate models reflecting the behavior of road users contributes to the reduction in congestion, the vehicles' travel time on the transportation network, fuel consumption, and emissions, which in turn support understood energy savings. The article proposes a model that allows for the estimation of the maximum queue size at the signal-controlled intersection approach (the so-called maximum back-of-queue). This model considers the most important traffic characteristics of the vehicles forming this queue. These traffic characteristics include the volume-to-capacity ratio, the capacity-to-starts ratio, the initial queue length on a given time interval, the green effective period ratio, the cycle length of a given interval, and the arrival flow rate of a given interval. The verification allowed the authors to conclude that the proposed model is characterized by high compliance with the actual traffic and road conditions at the intersections with signal controllers located in built-up areas in Poland. The obtained compliance confirms the possibility of using the model for practical applications in calculating the maximum back-of-queue at signal-controlled intersections located in built-up areas in Poland.

In [8], the authors presented their investigation of the impact of dynamic travel time information on drivers' route choice in an urban area—a case study based on the city of Białystok. Increasing traffic volumes in cities lead to common traffic congestions building up, especially during peak hours. To protect city dwellers from excessive fuel exhaust and traffic noise and to prevent drivers from time loss due to overloaded routes, it is important to inform them about real-time traffic conditions and possible delays in advance. Effectively influencing drivers' decisions to divert from an original route choice in case of traffic hinderance is essential, and the application of dynamic travel information in the form of variable message signs (VMSs) is believed to be effective in these terms. The paper examined drivers' willingness to divert from an initial route choice due to the information provided on VMS boards. Their behavior was analyzed in terms of their response to everyday and artificially elongated travel times displayed on the VMSs. Maximum simulated elongation reached 200% and 300% of the initial state, depending on the characteristics of the pre-peak conditions. To assess the effectiveness of VMSs, the changes in traffic intensities were statistically analyzed. In general, apart from few significant differences, the results revealed drivers' ignorance of the travel time information provided on the VMS, regardless of the extension of the original times.

J. Paszkowski et al., in their paper [9], present the problem of modelling the effects of traffic-calming introduction to volume–delay functions and traffic assignment. Traffic calming is introduced to minimize the negative results of motor vehicle use, for example, lower safety levels or quality of life, high noise levels, and pollution. It can be implemented through the introduction of road infrastructure reducing the velocity and the traffic volume. In this paper, they studied how traffic-calming influences the traffic assignment. For the research, a traffic-calming measure of speed cushions on Stachiewicza street in Krakow was taken. A method of extracting trajectories from aerial footage was shown, which

was further used to build a model. For a given example, through driving characteristics research and microscopic modelling, volume–delay functions given by the Bureau of Public Roads (USA) were estimated for a street with and without traffic calming. Later, a toy network of two roads of the same length, connecting the same origin and destination, was simulated using an equilibrium traffic assignment method. Simulations were conducted both with the use of PTV Vissim and Visum software and through individual calculations. According to the results of this paper, there was a difference in traffic volumes according to the equilibrium traffic assignment in the aforementioned toy network as a function of the network's total traffic volume.

V. Naumov and M. Pawluś, in the paper [10], identified the optimal packing and routing to improve last-mile delivery using cargo bicycles. Efficient vehicle routing is a major concern for any supply chain, especially when dealing with last-mile deliveries in highly urbanized areas. In this paper problems considering last-mile delivery in areas with the restrictions of motorized traffic are described, and distinct types of cargo bikes were reviewed. The paper described methods for solving a combination of problems in what concerns the cargo bicycle logistics, including efficient packing, routing, and load-dependent speed constraints. Proposed models apply mathematical descriptions of problems, including the Knapsack Problem, the Traveling Salesman Problem, and the Traveling Thief Problem. Based on synthetically generated data, they examined the efficiency of the proposed algorithms. Models described in this paper were implemented in Python programming language and can be further developed and used for solving the problems of electric cargo bikes' routing under real-world conditions.

Moreover, A.A. Drabicki et al. [11] evaluated the impact of public transportation service disruptions upon passenger travel behavior in Krakow City. Public transportation (PT) service disruptions are common and unexpected events which often result in major impediments to passengers' typical travel routines. However, attitudes and behavioral responses to unexpected PT disruptions are still not fully examined in state-of-the-art research. The objective of this study was to understand how PT users adapt their travel choices and what travel information sources they utilize once they encounter sudden PT service disruptions. To this end, the authors conducted a passenger survey among PT users in the city of Kraków (Poland), consisting of a series of stated- and revealed-preference questions. The results showed that passengers' reported choices during past PT disruptions mostly involved adjusting the current PT travel routine, exposing a certain bias in their stated choices (which tend to overestimate the probability of modal shifts). Factors influencing travel behavior shifts included the frequency and recency of PT disruption experience, as well as the propensity to arrive on-time. With regards to travel information sources, staff announcements and personal experience appeared to play a key role in recognizing the emerging disruption, but real-time information (RTI) sources were showed to be the most useful in planning the onward journey after such events. Based on these results, the study highlighted the implications for future RTI policy during PT service disruptions: in particular, the provision of a reliable time estimate until normal service conditions are resumed. Such RTI content could foster passengers' tendencies to use PT services in uncertain conditions, especially as their stated wait time tolerance often matches the actual duration of PT disruptions.

In the next paper, prepared by J. Oskarbski et al. [12], a bicycle traffic model for sustainable urban mobility planning has been proposed. Modelling tools and transportation models are required to assess the impact of measures for the effective planning of cycling routes in cities. This paper introduced the methodology for developing a four-stage macroscopic model of bicycle traffic for the city of Gdynia (Poland) and its use in planning new bicycle routes, considering a modal shift. The model presented in this paper allows for the evaluation of the influence of the characteristics of the cycling infrastructure, along with the development of the cycling network based on the choice of cycling as an alternative to other modes of transportation, by considering the modal shift. The model incorporated the influence of the longitudinal gradients, links, and surface types of cycling routes on the

distribution and demand for bicycle traffic. The results of this research allowed the authors to assess the impact of planned cycling routes on the reduction in the volume of car traffic, which is crucial for reducing energy consumption and negative environmental impacts. Experiences from the application of the model in Gdynia suggested that the model provides a strong basis to support mobility planning and monitoring processes in cities worldwide.

D. Biernacki and Ch. Lis in [13] studied the sustainable effects of urban-port road system reconstruction. The aim of the research was to identify and quantify the direct sustainable effects resulting from the improved road infrastructure in the local urban port system. This case study considered the city port of Szczecin (Poland). The effects were identified for the local road transportation system by comparing freight road transportation performance in two options: (i) with investment and (ii) without investment. The sustainable effects were quantified in terms of money and physical units. Sustainable economic, social, and environmental effects concerned generalized freight road transportation costs, i.e., truck operating costs and costs of truck drivers' working time, as well as freight transit time, energy consumption, greenhouse gas emissions, and environmental savings. To capture these effects, the forecasted truck traffic demand, unit vehicle operating costs, values of time, and air pollution and climate change values were elaborated and revealed in freight road transportation. The findings revealed that the primary effect of investment is the reduced traffic congestion, which enhances the velocity of trucks in the transportation system.

H. Fu-Shiung [14] compared three ridesharing cost-saving allocation schemes based on the number of acceptable shared rides. Shared mobility based on cars refers to a transportation mode in which travelers/drivers share vehicles to reduce the cost of the journey, emissions, air pollution, and parking demands. Cost savings provide a strong incentive for the shared mobility mode. Since the cost savings are due to the cooperation of the stakeholders in shared mobility systems, they should be properly divided and allocated to relevant participants. The improper allocation of cost savings will lead to the dissatisfaction of drivers/passengers and hinder the acceptance of the shared mobility mode. In practice, several schemes based on proportional methods to allocate cost savings have been proposed in shared mobility systems. Neither a guideline for selecting these proportional methods has been prepared nor a comparative study on effectiveness of these proportional methods. Although shared mobility has attracted much attention in the research community, there is still a lack of research of the influence of cost-saving allocation schemes on the performance of shared mobility systems. Motivated by the deficiencies in existing studies, this paper examined three proportional cost-saving allocation schemes by analyzing their performance in terms of the numbers of acceptable rides under different schemes. The authors focused on ridesharing based on cars in this study. The main study contribution relied on the development of a theory based on analysis to characterize the performance under different schemes to provide a guideline for selecting these proportional methods. The developed theory was verified by conducting experiments based on real geographical data.

In the next paper [15], an evaluation of the use of radar speed cameras and panels indicating vehicle speeds as traffic-calming measures (TCM) in short-length urban areas located along rural roads was performed. TCMs are typically implemented in urban areas to reduce vehicles' speeds. However, speed is still a problem in rural roads crossing small villages without a bypass and in short-length urban areas, since drivers do not normally reduce their speed for that short segment. Hence, various TCMs can be installed. It is necessary to maintain a calm area in these short segments to improve road safety, especially for pedestrians aiming to cross the road, and to save combustibles by avoiding a constant increase–decrease of speed. Four villages were selected to evaluate the efficiency of radar speed cameras and panels indicating vehicle speed. The results showed that the presence of radar speed cameras reduces the speed in the direction they can fine speeding cars, but with a lower effect in the non-fining direction. Additionally, a positive effect was observed in the fining direction in other points, such as pedestrian crossings. Nevertheless, the effect does

not last long, and speed cameras may be considered as punctual measures. If the TCMs are placed far from the start of the village, they are not respected. Hence, it is recommended to place them near the real start of the build-up area. Lastly, it was verified that longer urban areas make the overall speed decrease. However, when drivers feel that they are arriving to the end of the urban area, signaled by the lack of buildings, they start to speed up.

The last paper [16] is devoted to assessing the environmental performances of urban roundabouts using the Vehicle Specific Power (VSP) methodology and AIMSUN. In line with globally shared environmental sustainability goals, the shift towards citizen-friendly mobility is changing the way people move through cities and road-user behavior. Building a sustainable road transportation requires design knowledge to develop increasingly green road infrastructures and monitoring the environmental impacts from mobile crowdsourced data. In this view, the paper presents an empirically based methodology that integrates the VSP emission model and AIMSUN microscopic traffic simulation to estimate second-by-second vehicle emissions at urban roundabouts. The distributions of time spent in each VSP mode from instantaneous vehicle trajectory data gathered in the field via smartphone were the starting points of the analysis. The versatility of AIMSUN in calibrating the model parameters to better reflect the field-observed speed-time trajectories and to enhance the estimation accuracy was assessed. The conversion of an existing roundabout within the sample into a turbo counterpart was also made as an attempt to confirm the reproducibility of the proposed procedure. The results shed light on new opportunities in the environmental performance evaluation of road units when changes in design or operation should be considered within traffic management strategies and highlighted the potential of the smart approach in collecting massive amounts of data through digital communities.

3. Conclusions

Based on the collection of articles in this Special Issue, it can be concluded that the topics discussed in the articles most often concerned such issues as the use of traffic-calming measures and their effectiveness, human factors in road traffic and transportation engineering, bicycle traffic and infrastructure, the environmental impacts of transportation systems, as well as sustainable urban public transport.

In conclusion, we believe that this research topic presents a broad range of conceptual and practical research and reviews and that the papers included in this Special Issue clearly contribute to expanding the knowledge in this field. Moreover, we hope that the presented collection of articles will find a wide audience among scientists dealing with new perspectives and challenges in traffic and transportation engineering in support of energy saving in smart cities, as well as among practitioners dealing with this subject. Taking advantage of this opportunity, we wish all of you a fruitful reading.

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