POLITEHNICA UNIVERSITY OF BUCUREŞTI
Doctoral school: **TRANSPORT ENGINEERING**

ABSTRACT

Habilitation thesis

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CONTRIBUTIONS TO ROAD TRAFFIC MODELING

(CONTRIBUŢII LA MODELAREA TRAFICULUI RUTIER)

The paper constitutes the habilitation thesis and presents synthetically the main original scientific results and professional achievements in the doctoral field concerned, after obtaining the title of PhD in Automotive Engineering domain, in the year 2000, for the doctoral thesis entitled “Theoretical and experimental study of maintaining the reliability of transmission aggregates through maintenance works”.

The thesis indicates the evolution of the academic, scientific and professional career between 2000 and 2020, as well as the main directions of the development provided for the near future, based on the achievements significant and current scientific studies made in the field of Transport Engineering.

The ability to coordinate research teams, to organize and manage teaching activities, to explain and facilitate learning and research is also presented.

In the first part of the abilitation thesis are presented the main original scientific results and professional achievements published after obtaining the doctorate, in the field of doctorate Transport Engineering

After I was awarded the title of PhD for the doctoral thesis titled, in 2000 year, I continued my professional career in the Automotive Department of the University of Piteşti: in 2001 I became an associate professor, and in 2004 I received the title of university professor.

The academic career can be summarized through the academic positions I have fulfilled after obtaining the title of university professor:

• 2004-2008: Director of the Department for the Quality of Education of the University of Pitesti;

• 2008-2011: Head of the Department of Automobiles - University of Pitesti;

• 2012-2016: Vice Dean for Teaching Activities - Faculty of Mechanics and Technology.

The main original scientific results and professional achievements in the field of Transport Engineering, published after conferring the title of doctor so far have been obtained in the context in which we have carried out various research, guidance or coordination activities:

• Coordination of the license program in Transport and Traffic Engineering;

• Methodological guidance of the university driving school;

• Coordinating and conducting studies and research for the modernization of the public transport in Pitesti;

• Coordinating and conducting studies and research in order to expand public transport through regular services in the Pitesti metropolitan area;

• Designing public passenger transport programs through regular services for Vâlcea, Argeş, Dolj, Olt and Dâmboviţa counties;

• Designing public passenger transport systems through regular services in the peri-urban area of Pitesti;

• Coordination and realization of road traffic studies in Piteşti municipality, Câmpulung municipality and Bistriţa municipality;

• Collaboration with Piteşti City Hall and Argeş County Council for road infrastructure projects;

• Constant participation in the annual congresses organized by the Romanian Society of Automobile Engineers;

• Guidance for foreign students in internships and doctoral students in the laboratory of Transport, Road Traffic and Traffic Safety;

• Participation in ARACIS commissions for the evaluation of study programs in the field of Transport Engineering;

• Participation in competition commissions for teachers and doctoral commissions in the field of Transport Engineering.

In a synthetic way, the achievements in the field of doctorate Transport Engineering in the period after obtaining the doctorate are, according to the list of relevant papers in this field, the following:

A. Books: 5;

B1. Articles in journals and indexed proceedings ISI Thompson Reuters: 14;

B2. Articles published in national journals and volumes of scientific events indexed in BDI recognized by the CNATDCU commission: 37;

B3. Articles published in national journals and volumes of national and international scientific events, not indexed: 11;

D1. Research contracts (director / manager): 8;

D2. Research contracts (team member): 15.

In the second part of the thesis is made the scientific presentation of the topic that is the subject of the thesis - Contributions to modeling road traffic at roundabouts, highlighting in particular the scientific contributions resulting from scientific research.

In the first chapter are presented and analyzed the main concepts used in road traffic modeling:

• Microscopic parameters, which describe the individual behavior of vehicles or pairs of vehicles within the road flow: speed of individual vehicles; vehicle intervals; overcoming process parameters.

• Macroscopic parameters, which describe the overall road flow: traffic volume; traffic density; flow rate.

In order to elucidate the ambiguities regarding the order relation between the temporal average velocity and the spatial average velocity, theoretical researches have been developed for the two possible cases: the variable speed movement of a single vehicle, respectively the variable speed movement of a vehicle flow, and edifying theoretical results have been reached:

• in the case of a single vehicle, the average temporal speed is always lower than the average spatial speed;

• in the case of a flow of vehicles, the average temporal speed is always higher than the spatial average speed.

An extensive theoretical analysis was performed for the overtaking process, for which, given the obligations imposed by road legislation and the possibilities offered by the entire system "driver - vehicle - road", there may be 3 scenarios for overtaking in relation with visibility and accessibility (for the overtaking vehicle) and with the density of the flow of vehicles on its direction of travel.

It has been reported that in the most complex scenario - overtaking, followed by reintegration of the vehicle into the vehicle flow - a final phase occurs, when the overtaking vehicle moves at a speed equal to that of the overtaken vehicle - phase required for the vehicle to reintegrate into the flow of vehicles. This phase is not found in the overtaking maneuver models in the literature, but it is not to be neglected, because the space and time required to return to its lane, after the vehicle has reduced its speed to that of the flow of vehicles on its direction of travel, have quite important values.

In addition, an aspect that is not presented in the literature was revealed: the well-known relationship in which the speed in the fundamental equation of traffic is a harmonic average speed (spatial average speed) is valid only in the case of traffic flows (and not in the case of the single vehicle ie only when processing data on traffic flows and speeds.

Chapter 2 provides a comparative analysis of the various models used in the literature for the basic traffic diagram (uni-regime models: Greenshields, Greenberg, Underwood,

Northwestern; multi-regime models: Edie, linear-two regimes, modified Greenberg, linear-three regimes ...), concluding that the improvement of these models can be achieved only by taking into account the tracking models of vehicles, which involves the microscopic modeling of road flows.

It has been shown that in order to obtain a maximum volume of traffic it is necessary to ensure conditions for maintaining a minimum distance between vehicles, and this is achieved only in the case of homogeneous traffic (when the vehicles are of the same category, so they have dynamic and braking performance similar).

For this case it is concluded that the only factor that makes the difference in terms of the required distance between vehicles is the behavior of drivers through the reaction time

For the case of inhomogeneous traffic (with composite structure of vehicles, which have significantly different acceleration and deceleration possibilities), frequently encountered in our country due to the deficit of highways, the mathematical model that described the minimum interval between vehicles was developed based on the relationship the minimum interval between vehicles taking into account the difference between the braking modes of vehicles in the road flow (different decelerations).

Thus, the value for the minimum distance between two successive vehicles was defined according to the parameters that define the movements of the two vehicles (speed, reaction time of the driver, decelerations of the two vehicles and safety space) and finally came to make explicit the maximum traffic volume according to a quantity containing the decelerations of the two vehicles, which determined the proposal to use this quantity as a new term in road traffic theory: A = coefficient expressing the variability of braking decelerations for vehicles in the flow continuous composite, this coefficient having as equivalent the inverse of the deceleration.

This showed that in the case of inhomogeneous traffic the volume of traffic increases only up to a certain speed value (the lower the more inhomogeneous the traffic), after which it decreases, while for the case of homogeneous traffic, the volume of traffic continues to increase permanently with speed, but the growth fades to high values, when the volume of traffic tends asymptotically to a limit value that depends on the value of the reaction time of drivers.

Chapter 3 is dedicated to modeling traffic at roundabouts. The ambiguities generated by the fact that the Romanian literature is inspired by the Anglo-Saxon literature, where the road traffic is on the left, which led some norms to use wrong notations for the intersection arms and, as a result, the calculation relations must be carefully applied.

Interest was raised in the following question: is it possible for a roundabout, based on values measured with fixed observers for inflows, outflows and conflict flows, to determine the volume of traffic currents?

This problem was analyzed to find out if it was solvable and the conclusion was reached: for 3-arm intersections with return flows and for 4-arm intersections without return flows it is possible to know completely the traffic currents based on the flows measured with fixed observers (which must include right turn flows).

Based on the two sets of analytical relations obtained, two calculation programs were created in the Java programming language, with very accessible interfaces.

Continuing the theoretical exploration of the problem, it was found that it is possible to make a calculation program for the more complex situation in which the peak hourly factor PHF (Peak Hour Factor) is taken into account and two calculation programs were made in Microsoft Excel, the sizes output being the volumes of traffic currents corrected according to the values of the peak hourly factor PHF.

The most used method for validating traffic patterns is based on the statistical GEH indicator, defined by a relatively simple mathematical relationship, but which is not very noticeable and whose limit values are set for validating traffic models are of little relevance.

For this, a much more perceptible presentation of the GEH indicator was made, by highlighting the correlation between the GEH indicator and the percentage deviation between the estimated traffic volume and the measured traffic volume.

Chapter 4, Microsimulation of road traffic, reveals that traffic microsimulation models simulate the behavior of individual vehicles within a predefined road network and that Mcrosimulation has the greatest utility in modeling traffic in congested road networks, due to its ability to simulate conditions formation of queues.

Microsimulation is a term commonly used in traffic modeling, being known rather by the name of various software packages used in the field: TransModeler, PTV VISSIM, TSIS-CORSIM, Cube Dynasim, LISA +, Quadstone Paramics, SiAS Paramics, Simtraffic, Aimsun

Using the Vissim software, a complex application for road traffic analysis in the central area of Pitesti is created by microsimulation.

It was highlighted that in order to microsimulate the road traffic, it is necessary to take into account the characteristics of the intersection, of the vehicles and of the drivers. Thus, considering that in Pitesti the car park is quite efficient and the drivers are quite dynamic, it is recommended to adopt low values both for the time of interference in the traffic on the circular lane and for the time of succession at the entrance to the intersection from the arm.

In the next chapter - Integrated models for the evaluation and analysis of road traffic in road intersections, it was revealed the need to conduct traffic analysis not only at the intersection for which it is desired to improve the service level, but for a larger area nearby, allowing analysis scenarios in which it is proposed to divert some of the flows from the intersection, given that currently microsimulation programs have reached the performance of performing simultaneous analysis at these dimensions.

These modern researches were based on the equipment purchased through contracts won in the internal scientific research competition for young people, organized annually at the University of Pitesti, by young colleagues from the laboratory "Transport, Road Traffic and Traffic Safety" which I coordinate.

The proposed traffic diversion is certainly the most efficient solution, both in terms of reducing road congestion in the area and as an investment, practically requiring only the modification of road sign.

In the last chapter are presented the main conclusions and the original results obtained through the research presented previously.

In the third part of the paper is presented the scientific and academic development plan, predicted based on the concerns and results so far, but also on the openness offered by obtaining the habilitation in the field of Transport Engineering.

Thus, the research directions that I intend to develop, mainly through the guidance of doctoral students, have in mind the capitalization of the very valuable scientific experience of the doctoral school, but also the need to contribute to expanding the issues addressed and the level of knowledge in the field. .

An important direction that I want to develop is that of guiding students in international co-supervision, and I will promote at this level the international relations that I have developed with faculties that have study programs in the field of Transport Engineering

I hope that by implementing the development plan, in which the research activity and the guidance of doctoral students have a special importance, as a doctoral supervisor I will be an active factor for increasing the performances of the doctoral school.