

HABILITATION THESIS ABSTRACT

SMART SUSPENSION SYSTEMS FOR EFFICIENT AND SUSTAINABLE ROAD TRANSPORT

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This habilitation thesis summarizes the main scientific, didactic, and managerial achievements obtained subsequent to the defense of the doctoral thesis. The research is integrated into the fundamental field of Engineering Sciences, the specific domain of Transport Engineering. Its central objective is the dynamic optimization, energy efficiency, and enhancement of vibratory comfort in transport systems through the implementation of semi-active and active suspensions equipped with magnetorheological (MR) and electrohydraulic (EH) dampers. The work is structured into five main chapters, reflecting a unitary approach that spans from the current state of the art in the field to the development of custom experimental infrastructure and academic management strategies.

Chapter 1 analyzes the current state of research in the field of semi-active suspensions at an international level, highlighting modern trends of replacing classical systems with smart adaptive solutions capable of responding in real time to road profile variations to ensure transport fluidity and sustainability.

Chapter 2 addresses the fundamental aspects regarding suspension comfort, defining its role and functions within the overall dynamics and safety of road vehicles. The primary excitation sources for automobile oscillations are mathematically analyzed, focusing on the road profile and the non-uniformities or imbalances of the axles and running gear. Furthermore, the chapter provides the theoretical foundation for the mathematical modeling of the vehicle-road interaction through a comparative analysis of three established models: the quarter-car model, the half-car model, and the full-car model, which are fundamental for evaluating transport quality.

Chapter 3 is dedicated to the construction, operation, and classification of semi-active suspensions for road vehicles. Electrohydraulic, electrorheological, and magnetorheological solutions are comparatively evaluated. Special attention is given to magnetorheological systems, analyzing advanced control strategies (semi-active control and PID algorithms), the influence of additives used in the composition of MR fluids for chemical stability, as well as the mathematical modeling of the monotube

magnetorheological damper as a core element in enhancing rolling energy efficiency.

Chapter 4 focuses on custom experimental research conducted on semi-active suspensions. This section presents in detail the design and experimental development of two innovative laboratory test rigs (for testing passive/semi-active and active suspensions), finalized through the successful management of research grants won through competition (GEX 2016 and ARUT 2023). The main experimental results are disseminated, validating the numerical models and highlighting the correlations between the control electrical current intensity, the excitation signal, and the generated damping force, with applications in optimizing consumption and road traffic safety.

Chapter 5 synthesizes the scientific, professional, and academic achievements, highlighting the career evolution from the position of Associate Professor. It emphasizes the publishing activity (31 reference papers indexed in WOS/BDI; 8 books and laboratory guides published at Politehnica Press, the Military Technical Academy "Ferdinand I", and Matrix Rom; 1 conference proceedings volume), as well as an intense didactic activity in specialized disciplines (Braking, Steering, and Suspension Systems, Automotive Mechanical Systems, and Management, Automotive Construction and Calculation – project II). The international dimension of the career is supported by active participation in prestigious international conferences held in countries such as India and Bulgaria. Professional recognition within the academic community is attested by serving as a member of examination committees for Bachelor's degree graduation and by being appointed as a committee member in selection competitions for awarding the title of Associate Professor to two peer colleagues within the Military Technical Academy "Ferdinand I". Additionally, it integrates the pedagogical vision of attracting students to the Automotive Engineering Automotive Engineering and Automotive Propulsion Systems Engineering programs through laboratory modernization, the experience accumulated by supporting and actively collaborating with PhD student teams, concluding with clear perspectives for research development as a future doctoral supervisor. Future advising activities will strategically focus on three main research directions:

- **Elastokinematics of axle and suspension systems in the dynamics and comfort of sustainable road transport;**
 - *Field of study:* Researching the interactions between axle geometry, elastic deformations of components, and smart suspension systems, aiming to optimize vibration isolation, road infrastructure protection, and transport quality enhancement.

- **Dynamics of advanced steering and braking systems in road traffic safety;**
 - *Field of study:* Analyzing the kinematic and dynamic behavior, as well as the integrated control of steering and braking systems, aiming to substantiate modern vehicle stability strategies as a central pillar in increasing active traffic safety.
- **Management of decarbonization, energy recovery, and consumption efficiency in sustainable road transport.**
 - *Field of study:* Applying operational and strategic management principles to implement energy recovery technologies during braking, monitoring energy flows, reducing the fuel consumption of vehicle fleets, and minimizing greenhouse gas (GHG) emissions.