Commencement of Study: 1. March 2026

Department of Applied Mathematics (K611)

Study programme*: *Transportation Systems and Technology

Supervisor:
doc. Ing. Michal Matowicki, Ph.D. (e-mail contact: michal.matowicki@cvut.cz)

Topic:
Safety Assurance for Autonomous Train Operations

Language:
English

Abstract:
The deployment of autonomous train systems promises to revolutionize rail transport by increasing capacity, reducing operating costs, and improving service reliability. However, ensuring the safe integration of such systems into complex rail environments remains a critical challenge. This research aims to develop a systematic safety assurance framework for autonomous train operations, with particular emphasis on high-grade automation (GoA3 and GoA4) within mixed traffic and legacy infrastructure settings. The dissertation will explore existing formal safety assessment methodologies, including hazard identification, risk evaluation, and safety case development, aligned with Common Safety Methods (CSM) and EN 50126/50128/50129 standards, and evaluate their potential in massive systematic changes due to autonomous operation. Special focus will be given to digital signalling integration, onboard obstacle detection, fail-safe operation under degraded modes, and human-machine interface design for remote supervision. The research will also incorporate simulation-based safety validation, system-theoretic process analysis (STPA), and real-world data from pilot autonomous operations, including those within the Europe's Rail Joint Undertaking. Outcomes are expected to contribute to both academic literature and regulatory practice by proposing a scalable and verifiable safety framework tailored for next-generation railway automation.

References:
1. Chelouati, M., Boussif, A., Beugin, J., El Koursi, M., Graphical Safety Assurance Case Using Goal Structuring Notation for Autonomous Train Operations. Safety Science (2020), 157, Article 105948.
2. Hunter, J., McDermid, J., & Burton, S., Safety Analysis of Autonomous Railway Systems: An Introduction to the SACRED Methodology (2023). arXiv preprint.
3. Matowicki, M., & Torun, A. (2024). The Application of Common Safety Method to Evaluate Migration to Autonomous Railway Operation - Discussion. Proceedings of the Sixth International Conference on Railway Technology: Research, Development and Maintenance, Edinburgh, Civil-Comp Press, pp. 1-8.
4. Chelouati, M., Conributions to safety assurance of autonomous trains, Automatic Control Engineering. Université Gustave Eiffel, 2024. English.

Number of doctoral students: 1

Form of study: **full-time**

Commencement of Study: 1. March 2026

Department of Mechanics and Materials (K618)

Study programme: ***Transportation Systems and Technology***

Supervisor: **prof. Ing. Ondřej Jiroušek, Ph.D. (e-mail contact: jirousek@fd.cvut.cz)**	
Topic: **AI-Driven Impact Mechanics of 3D-Printed Optimized Bio-Inspired Structures**	
Language: **English**	
Abstract: **This PhD project focuses on leveraging artificial intelligence (AI) to enhance the understanding and predictive modeling of impact mechanics in 3D-printed bio-inspired structures. By integrating AI-based optimization techniques with finite element simulations and experimental validation, the research aims to develop novel materials and structural designs with superior energy absorption and impact resistance. The study will explore bio-inspired architectures, additive manufacturing techniques, and AI-driven surrogate modeling to accelerate the identification of optimal configurations for high-performance applications. The work involves close collaboration between computational modeling, machine learning, and experimental impact testing, making it ideal for candidates with a background in mechanical engineering, computational mechanics, or materials science.**	
References: **1. Zeng, C., Liu, L., Bian, W., Leng, J., & Liu, Y. (2021). Compression behavior and energy absorption of 3D printed continuous fiber reinforced composite honeycomb structures with shape memory effects. Additive Manufacturing, 38, 101842. https://doi.org/10.1016/j.addma.2021.101842** **2. Peng, B., Wei, Y., Qin, Y., Dai, J., Li, Y., Liu, A., Tian, Y., Han, L., Zheng, Y., & Wen, P. (2023). Machine learning-enabled constrained multi-objective design of architected materials. Nature Communications, 14(1), 6630. https://doi.org/10.1038/s41467-023-42415-y** **3. Katiyar, N. K., Goel, G., Hawi, S., & Goel, S. (2021). Nature-inspired materials: Emerging trends and prospects. NPG Asia Materials, 13(1), 56. https://doi.org/10.1038/s41427-021-00322-y**	
Number of doctoral students: 1	
Form of study*:** ***full-time	

Supervisor:
doc. Ing. Daniel Kytýř, Ph.D. (e-mail contact: kytyrd1@fd.cvut.cz)
(školitel specialista doc. Ing. Tomáš Fíla, Ph.D.)

Topic:
Laboratory based X-ray imaging techniques with very high temporal and spatial resolution

Language:
English

Abstract:
Actual challenges in the state-of-the-art in-situ X-ray imaging can be divided into the following key goals: to increase spatial resolution, to increase temporal resolution, to reduce scanning time, to get high quality visualizations of problematic materials, e.g., low attenuation materials like biological tissues, or materials with very different phases like polymers with metal reinforcements, and to keep costs of the measurement in a reasonable range. While the technical challenges can be overcome in particle accelerators like synchrotrons with very high costs, it is extremely demanding task in versatile laboratory based X-ray systems but with application potential. The topic of the dissertation is a development of a laboratory based X-ray computed tomography system for in-situ material testing with unprecedently high temporal and spatial resolution. To achieve this goal, a state-of-the-art liquid anode X-ray source will be integrated together with a variety of radiation imaging systems, detectors, and in-situ devices, while all the elements will be synchronized in real-time. The system will be combined with advanced data processing and post-processing methods allowing for automated analysis of large datasets, e.g., identification and tracking of damage in the material microstructure. The capabilities of the system will be demonstrated on representative applications studying time-dependent processes in biomechanics and material engineering.
The dissertation will be performed in close co-operation and sharing of research infrastructure between Department of Mechanics and Materials FTS CTU and Department of Biomechanics ITAM CAS

References:
E.A. Zwanenburg et al.: Review of high-speed imaging with lab-based x-ray computed tomography, Measurement Science and Technology, 2022, 33(1), DOI:10.1088/1361-6501/ac354a
B. Nurel, et. al., Split Hopkinson pressure bar tests for investigating dynamic properties of additively manufactured AlSi10Mg alloy by selective laser melting, Additive Manufacturing, Volume 22, 2018, pp 823-833, doi:10.1016/j.addma.2018.06.001.

S.C. Garcea et al.: X-ray computed tomography of polymer composites, Composites Science and Technology, 2018, 156, DOI:10.1016/j.compscitech.2017.10.023
L. Xuekun et al.: Anisotropic Crack Propagation and Deformation in Dentin Observed by Four-Dimensional X-ray Nano-Computed Tomography, Acta Biomaterialia, 2019, 96(3), DOI: 10.1016/j.actbio.2019.06.042

Number of doctoral students: 1

Form of study: full-time