



IEEE ITSC 2025

Invited Session Proposal

- **Title:**

[Control, Communication and Emerging Technologies in Smart Rail Systems]

- **Modality:**

[Half-day (e.g., 3 hours plus breaks)]

- **Scope:**

- Motivation and general scope

Rail transport networks are now reaching an important development stage worldwide. High-speed rail transport systems have achieved significant development in Europe and Asia and are becoming popular in many countries. Metropolitan transport will become increasingly important in the coming years for reducing pollution and congestion in cities. Both metropolitan and high-speed railways require the use of advanced signaling and control systems to guarantee and optimize their operation. For these reasons, it is necessary to use modern communication and signaling systems for the intelligent control of these railways. In addition, railway infrastructures use many supplementary systems such as remote control, video surveillance, obstacle detection, and operating aids that require the intensive use of information and communication technologies. In all cases, the electrical and electronics equipment must have a high quality of service, reliability, and availability to fulfill railway requirements.

The aim of this special issue is to present a collection of high-quality research papers on recent developments, current research challenges, and future directions in the use of control, communications, and emerging technologies to realize smart rail systems that are safer and more efficient. We are soliciting original contributions that have not been published and are not currently under consideration by any other journals.

- Relevance to the ITS community

This special session focuses on smart rail systems, a vital and evolving area within the ITS community. It highlights emerging technologies in control, communication, and intelligent monitoring—now further extended to include Large Language Models (LLMs) and embodied intelligence. These advances are expected to significantly enhance the autonomy, safety, and adaptability of rail transport, aligning closely with the ITS vision of intelligent, efficient, and sustainable mobility systems.

- Topics of interest for the invited session

The topics of interest include, but are not limited to:

- Autonomous rail system modeling and optimization
- Architectures, algorithms, and protocols for data dissemination, processing, and aggregation for smart rail systems

- Networked information processing, decision-making, and intelligent control for smart rails

- Smart railway communications and networking

- Wireless technologies for smart rail systems

- Advances in applications and services for smart rail systems

- Security, privacy, and dependability in smart rail systems

- Results from experimental systems, testbeds, and pilot studies for smart rails

- Intelligent transportation, rail traffic modeling, decentralized congestion control in smart rail systems

- Condition monitoring, fault detection and diagnosis for smart rail systems

- Advanced prognostics and health management technology for smart rail systems

- Large Language Model (LLM) for smart rail systems

- Embodied intelligence for smart rail systems



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- Organizers (names, affiliations, emails, and short bio):

Li Zhu, Beijing Jiaotong University, Beijing, China, lizhu@bjtu.edu.cn

Pro. Dr. Zhu received his Ph.D. degree in Traffic Information Engineering and Control from Beijing Jiaotong University in 2012. From 2009 to 2010, he was a visiting student at the University of British Columbia (UBC) and Carleton University in Canada, where he focused on research and development in advanced wireless communication technologies for railway control systems. He joined the State Key Laboratory of Rail Traffic Control and Safety at Beijing Jiaotong University in 2012, where he currently serves as a Professor. His research interests include train-ground communication systems, communication-based train control systems, cross-layer/cross-system design in wireless networks, and security in train control systems. He has published 127 papers in reputable journals and conferences, with most of them appearing in well-known journals such as IEEE Transactions on Vehicular Technology, IEEE Transactions on Intelligent Transportation Systems, and IEEE Journal on Selected Areas in Communications (JSAC). His doctoral dissertation, "Cross-Layer Design in CBTC Train-Ground Communication Systems," was awarded the Beijing Exceptional Doctoral Dissertation award.

As the head and coordinator of more than 10 projects funded by the Ministry of Education and the Natural Science Foundation, among others, Prof. Zhu has played a crucial role in research initiatives. He has served on the Technical Program Committee (TPC) of numerous conferences and as the TPC Co-Chair of IEEE ITSC' 14, IEEE ITSC' 15, IEEE ITSC' 16, IEEE ITSC' 19, and IEEE ITSC' 20, as well as a TPC member of Globecom' 14 and ICC' 14. Additionally, he has contributed as a reviewer for several renowned journals, including IEEE Transactions on Vehicular Technology, IEEE Transactions on Intelligent Transportation Systems, EURASIP Journal on Wireless Communications and Networking, Wiley Journal on Security and Communication Networks, and the International Journal of Wireless Communications and Networking. In the industrial domain, Prof. Zhu played a pivotal role as the main participant in designing the data communication system of the CBTC system for the Beijing Metro Yizhuang Line, which marked the first train control system with self-owned intellectual property rights. Throughout the system design process, he published four granted patents. His Google Scholar citations have reached 3,439, with an i10-index of 46.

Tao Tang, Beijing Jiaotong University, Beijing, China, ttang@bjtu.edu.cn

Pro. Dr. Tang received his Ph.D. degree in Automatic Control Theory and Application from the Chinese Academy of Sciences, Beijing, China, in 1991. He is currently a Professor with the School of Electronics and Information Engineering and the Chief Scientist of the State Key Laboratory of Advanced Rail Autonomous Operation, Beijing Jiaotong University. He has published over 200 research articles in various journals, such as the IEEE Transactions on Vehicular Technology, IEEE Transactions on Intelligent Transportation Systems, Transportation Research Part B-Methodological, Knowledge based-systems and refereed conferences. His current research interests include railway control systems and intelligent control theory of various types and autonomous train systems, with a dedication to facilitating the industrial implementation of related research. He is a Specialist with the National Development and Reform Commission and the Beijing Urban Traffic Construction Committee. He is also a Leader of the national key discipline Traffic Information Engineering and Control. Plus, he is a candidate for Academician of the Chinese Academy of Engineering.

Dr. Xiaoxi Hu, Beijing Jiaotong University, Beijing, China, xiaoxhu@bjtu.edu.cn

Xiaoxi Hu received his Ph.D. degree in Traffic Information Engineering and Control in Beijing Jiaotong University, Beijing, China, in 2025. He will be Postdoctoral Researcher in the State Key Laboratory of Intelligent Green Vehicle and Mobility, the School of Vehicle and Mobility, Tsinghua University, Beijing, China. His research interests include condition monitoring, fault detection and diagnosis and health management in the railway systems. He has published over 20 research articles in various journals, such as the IEEE Transactions on Intelligent Transportation Systems, Engineering Failure Analysis and IEEE ITSC conferences. He serves as a reviewer for IEEE ITS, IEEE TIM, IEEE TII, TMECH, IEEE Sensors Journal, MSSP, IMM, and Computers and Electrical Engineering. He served as the Chairman of Rail Transport and Rail Traffic Management for the 2023/2024 IEEE ITSC Conference.



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- List of potential contributors (including as much detail as possible):

1. Secure and Resilient Communication Architectures for Autonomous Railway Systems

Authors: Haoran Xu, Mingyu Zhao, Lijuan Sun

Haoran Xu, Beijing University of Posts and Telecommunications, Beijing, China

Mingyu Zhao, Beijing University of Posts and Telecommunications, Beijing, China

Lijuan Sun, Beijing University of Posts and Telecommunications, Beijing, China

2. Cross-Domain Federated Learning for Predictive Maintenance of Railway Traction Systems

Authors: Yuxuan Li, Tao Wen, Zhiqiang Chen

Yuxuan Li, Beijing Jiaotong University, Beijing, China

Tao Wen, Beijing Jiaotong University, Beijing, China

Zhiqiang Chen, Southwest Jiaotong University, Chengdu, China

3. Multi-Sensor Data Fusion for High-Precision Railway Track Condition Monitoring

Authors: Weihao Zhang, Chenhui Liu, Jing Shen

Weihao Zhang, Beijing Metro Construction Administration Co., Ltd, Beijing, China

Chenhui Liu, Zhejiang University, Hangzhou, China

Jing Shen, Shanghai Jiao Tong University, Shanghai, China

4. Transformer-Based Graph Neural Networks for Fault Detection in High-Speed Rail Signal Systems

Authors: Xiaochun Wu, Wenjuan Liu, Wei Li

Xiaochun Wu, Lanzhou Jiaotong University, Lanzhou, China

Wenjuan Liu, Lanzhou Jiaotong University, Lanzhou, China

Wei Li, Lanzhou Jiaotong University, Lanzhou, China

5. 3D Vision-Based Railway Intrusion Detection Using Multi-Modal Sensor Fusion

Authors: Chengwei Liu, Haotian Feng, Xinyi Zhou

Chengwei Liu, Tsinghua University, Beijing, China

Haotian Feng, Beijing Jiaotong University, Beijing, China

Xinyi Zhou, Southeast University, Nanjing, China

6. Panoramic Railway Scene Segmentation for Intelligent Infrastructure Monitoring

Authors: Zhenyu Wang, Jialiang Sun

Zhenyu Wang, Southwest Jiaotong University, Chengdu, China

Jialiang Sun, Beijing University of Posts and Telecommunications, Beijing, China

- Intended audience and expected attendance of the invited session:

[Rail Engineers, Rail Transit Student, Professors](#)

- Contact details of the main proposers (email & mobile number):

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