S.I.I.V. Working Group
GdL «S.I.I.V. Futura»

Advanced Topics in
Roads, Railways and Airports Engineering

Doctoral Lecture Series

2026

Summary

This document presents a proposal for a modular lecture series on Roads, Railways and Airports research designed for PhD students enrolled in Italian Doctoral Courses.
The initiative is promoted by the S.I.I.V. Working Group "S.I.I.V. - Futura", with the aim of fostering scientific exchange and interdisciplinary discussion on themes related to the Scientific Disciplinary Sector "Roads, Railways, and Airports".

General Structure

The lectures will include ten general topics, each addressing a specific area of research and innovation within the field of transport infrastructures. Each topic will be covered by a single lecture or a short series of lectures lasting approximately up to 8 hours maximum. The detailed list of topics and potential speakers will be defined and updated annually.

Lecturers

The lectures are primarily intended to be delivered by researchers and postdoctoral fellows under 40 years old who are members of the S.I.I.V.-Futura Working Group. However, participation is open to any interested scholar or faculty member willing to contribute to the initiative.

Language and Delivery Mode

The lectures will be conducted in English to promote accessibility and encourage participation from diverse doctoral programs.
Each lecturer will deliver a single session per year, hosted in one of the S.I.I.V. affiliated institutions, but preferably at their own institution. The teaching mode will be possibly blended:
- The session will be held in presence at the lecturer's selected university.
- A remote access link will be provided, allowing doctoral students from other institutions across Italy to attend online.

PhD students will also be free to attend in person at the hosting university if they wish (at their own charge).

Participation of Doctoral Schools

Each University Doctoral College will be free to decide whether to adhere to the initiative, including this cycle as a Doctoral Course or as a Seminar, and selecting which and how many topics to offer to its own students. The flexible structure of the program allows each institution to tailor participation according to its specific educational and research interests. For organizational purposes, S.I.I.V. will spread before the lectures a registration form to be filled in by interested participants. Interested participants will be required to complete the form, indicating whether they intend to attend the lecture in person or remotely.

List and brief description of Topics

    1. Road Safety
Design principles, safety assessment, risk analysis, and new approaches to accident prevention on road networks.

    2. Monitoring and Remote Sensing
Techniques and applications for structural health monitoring, deformation analysis, and performance tracking of transport infrastructures.

    3. ML / AI / Big Data / FCD
Application of machine learning, artificial intelligence, big data analytics, and floating car data for infrastructure management and mobility analysis.

    4. BIM / GIS
Digital modeling, information management, and geospatial integration for the design, construction, and maintenance of transport infrastructures.

    5. Innovative Materials
New construction and maintenance materials for pavements and structures, including performance-based design and testing.

    6. Green Materials
Use of recycled, bio-based, or low-impact materials for sustainable infrastructure solutions.

    7. LCA / Sustainability
Life Cycle Assessment and sustainability frameworks for evaluating the

environmental, social, and economic impacts of infrastructure projects.

8. Smart Infrastructures

Integration of sensors, IoT, and real-time data systems for intelligent infrastructure management.

9. Railways

Planning, design, maintenance, and technological innovation in railway infrastructures and operations.

10. Airports

Design, management, and sustainability of airport infrastructures, with focus on airside and landside integration.

General Topic	Road safety

Short description	The "Road safety" topic is related to two main fields of research: a) study, development and application of safety performance indicators and models, b) driving behavioral studies. This topic has several connections with other topics separately treated, such as smart infrastructures, GIS/BIM, monitoring, sustainability). It also involves other studies with specific objectives not included in the two latter fields, but anyway related to the interactions between road infrastructures, users, vehicles, traffic and environment which may lead to unwanted consequences for road users, such as traffic crashes of different severities. Regarding the latter, specific crash data analyses, including several variables and factors are of interest, with different focuses depending on the particular context (e.g., in presence of road works). For what concerns the first cited specific field of research, it includes the development and application of models able to predict traffic crashes and/or conflicts in both the urban and rural environment. It also relates to the development and application of techniques and indicators which may scientifically support road network safety management, with regard to black spot identification, intervention prioritization and selection and evaluation of countermeasures. In the urban environment, the study of crashes due to emerging trends, such as micro mobility vehicles, is considered. The study of conflicts may rely on the study of real movements and trajectories of monitored vehicles by means of different techniques. Another approach for achieving safety data (e.g., operating speeds) is to rely on floating car data. The second specific field of research includes all types of driving behavioral studies conducted with the help of different methods and for different road users (e.g., vehicle drivers, cyclists, pedestrians). In particular, driving simulators can be used in combination with different scenarios (realized also by using BIM-related tools) to study a wide list of safety-related aspects, such as mental workload, distraction, visual behavior, interactions with road design elements or between different road users (including vulnerable road users in the urban environment in shared or separated spaces).

Proposed Lectures	1) **Road safety advances from a safe system approach perspective** (2 hours) by **Paolo Intini (Università del Salento)** 2) **Assessing Human Performance in Driving through Innovative Technologies** (2 hours) by **Margherita Pazzini (Università di Bologna)**

General Topic	Monitoring and Remote Sensing *(Integrated Monitoring Solutions for Critical Infrastructure: Techniques, Sensors, and Digital Twins)*

Short description	The topic of these seminars is the monitoring of critical infrastructure through innovative technologies, with particular emphasis on remote sensing and multi-source data integration. Monitoring is essential to ensure the safety, resilience, and long-term performance of transport networks. In this context, remote sensing provides a non-invasive, scalable, and continuous means of observing structural behavior and detecting early signs of deterioration. The module presents advanced methodologies based on satellite Earth Observation (EO), including the use of active and passive sensors and interferometric techniques such as MT-InSAR for deformation analysis and change detection across road, rail, and airport infrastructure. It also addresses the integration of data from Non-Destructive Testing methods, including LiDAR, UAV surveys, and ground-based sensors, using spatial and temporal scaling algorithms. Real-world case studies involving highways, railways, and airports will be presented, highlighting current challenges and future perspectives. The concept of the Digital Twin is introduced as a dynamic, data-driven tool for predictive maintenance and intelligent infrastructure management. **Main Topics:** • Remote sensing technologies for transport infrastructure monitoring (road, rail, airport) • MT InSAR techniques for deformation analysis and change detection • Multi-source data fusion and spatial-temporal scaling: methods and case studies

Proposed Lectures	1) **Monitoring Techniques and Advanced Remote Sensing for Infrastructure Resilience** (2 hours) by **Valerio Gagliardi (Università Roma Tre)** 2) **Multi-Source Data Integration for Infrastructure Monitoring: UAV Surveys and the Digital Twin Frontier** (2 hours) by **Valerio Gagliardi (Università Roma Tre)**

General Topic	Machine Learning, Artificial Intelligence, Big Data and Floating Car Data (FCD) for Smart Transportation Infrastructures

Short description	The topic "Machine Learning, Artificial Intelligence, Big Data and Floating Car Data (FCD)" focuses on the development and application of data-driven models for the monitoring, analysis, and predictive assessment of transportation infrastructures. The research aims to exploit modern AI techniques to improve the understanding of physical–mechanical behavior of road materials, the performance of pavements, and the dynamics of road users. The seminars will explore the use of machine learning (ML) and deep learning approaches for predictive modeling of the mechanical properties of asphalt mixtures, enabling the estimation of their performance and durability under different loading and environmental conditions. Furthermore, time-series analysis methods will be discussed to interpret long-term deformation data, providing insights into structural degradation mechanisms and maintenance needs. Another focus area concerns the integration of large and heterogeneous datasets derived from different monitoring systems, including 3D imaging, laser scanning, mobile mapping, and 360° environmental imagery. These data are used to train computer vision and image analysis models for the automated detection of pavement distresses, structural defects, and safety-critical conditions. Such AI-based tools can significantly reduce monitoring costs and enhance maintenance planning strategies. A specific emphasis will be placed on Floating Car Data (FCD) — anonymized, high-frequency information collected from connected vehicles and mobile devices that provide real-time details on speed, position, and trajectory. FCD offer a valuable source of dynamic traffic information to support predictive modeling of road user behavior, enabling the detection of potential collision risks and real-time safety warnings through high-performance computing (HPC) systems. Overall, this topic bridges the fields of transportation engineering, data science, and artificial intelligence, promoting a digital and sustainable transformation of infrastructure management through advanced analytics and predictive technologies.

Proposed Lectures	1) **Predictive Modeling of Road User Behavior using FCD** (2 hours) by **Giulia Del Serrone (Sapienza Università di Roma)**

General Topic	Building Information Modeling (BIM) and Geographic Information Systems (GIS) for linear infrastructures

Short description	This doctoral seminar series offers a research-oriented overview of Building Information Modeling (BIM) and Geographic Information Systems (GIS) within the domain of transport infrastructure. The program introduces the theoretical foundations of both BIM and GIS, exploring their complementary roles in the planning, design, and maintenance of complex infrastructural systems through interoperable workflows and the integration of heterogeneous, multi-scale datasets. Participants will engage with Visual Programming Languages (VPL) in the context of Open Infrastructure BIM, acquiring methodological tools to translate geometric surveys into structured digital models and to incorporate data derived from Non-Destructive Testing (NDT). Applied components, including in-situ pavement testing and data integration applications, will be presented to highlight the relationship between multi-source data acquisition and digital representation. The seminar further examines the strategic potential of BIM-GIS interoperability in generating georeferenced infrastructure models that support advanced asset management, environmental impact assessment, and safety analysis across road, railway, and airport networks. Emphasis is placed on the development of integrated, research-driven methodologies that promote data interoperability, collaborative planning, and informed decision-making throughout the infrastructure lifecycle. Topics Covered: ● Theoretical foundations and principles of GIS and BIM ● BIM applications in road and transport infrastructure ● Introduction to Visual Programming Languages (VPL) ● Transition from geometric surveying to BIM modeling ● Incorporation of Non-Destructive Testing (NDT) data ● Management of multi-scale, multi-source, multi-sensor data ● GIS-BIM integration for infrastructure analysis and planning

Proposed Lectures	1) **BIM and GIS for Infrastructure: Toward an Integrated Digital Twin** (2 hours) by **Salvatore Antonio Biancardo (Università di Napoli Federico II)** 2) **Parametric BIM Design using Visual Programming Language** (2 hours) by **Mattia Intignano (Università di Napoli Federico II)** 3) **I-BIM approaches for road design and maintenance management** (2 hours) by **Giuseppe Sollazzo (Università di Messina)**

General Topic	Innovative materials
	(Non-Conventional Materials and Advanced Technologies in Pavement Engineering)

Short description	This topic explores recent advances in the study and application of innovative materials and construction techniques for road pavements, with a particular focus on non-conventional solutions designed to enhance mechanical performance, functionality, and durability. It provides a broad framework within which specific studies and research activities can be developed to investigate experimental, theoretical, or applied aspects of pavement innovation.
	A first area of interest concerns non-conventional and high-performance materials, such as polymer-modified binders, mixtures enhanced with chemical additives, and other new-generation binders. Within this context, attention is also given to advanced testing procedures, rheological and mechanical characterization, and predictive modelling aimed at describing the response of different pavement layers, both structural and surface, under various loading and environmental conditions.
	A second area focuses on performance evaluation of materials and pavements under innovative or unconventional scenarios, for example when the infrastructure includes integrated systems or technologies that may influence its behaviour. In this sense, pavements interacting with emerging technologies, such as monitoring and sensing systems or inductive charging devices, raise new questions regarding mechanical response, durability, and long-term serviceability. A third area deals with surface characteristics and functional layers, covering aspects such as skid resistance, texture evolution, and the design of thin and ultra
	thin surface treatments. These topics may involve both advanced laboratory and in-situ testing approaches, as well as numerical or analytical modelling of surface performance over time.
	Overall, the topic offers a flexible and comprehensive overview of current innovation trends in pavement engineering, encouraging the exchange of ideas and methods on advanced materials, testing techniques, construction practices, and modelling tools for the design and management of efficient, resilient, and long-lasting infrastructures.

Proposed Lectures	1) **Self-sensing asphalt composite with carbon microfibers for smart weigh-in-motion** (2 hours) by **Alessandro Corradini (Università di Perugia)**

General Topic	Green Materials

Short description	The topic about "Green materials" addresses several aspects connected to the design, characterization and application of innovative materials, with a focus on reducing environmental impacts while guaranteeing adequate mechanical and functional performance of transport infrastructures. The theme can cover research and implementation about new binders (e.g., high-modified bitumens, bio-based binding materials, etc.), alternative aggregates (e.g., recycled, manufactured, etc.) and innovative mixtures (e.g., with low-impact sources, with eco-friendly production techniques, etc.), with the main target to promote circular economy principles in transport construction and maintenance practices. With respect to the reuse and valorization of secondary raw materials, possible focusses can include the reclaimed asphalt pavement (RAP), the construction and demolition waste (CDW), the industrial by-products (e.g., ashes, slags) and the waste plastics. Optimized mix designs, activation processes and durability improvement are expected to be emphasized also in view of the most recent regulations and technical requirements established at national and international governmental levels to reduce carbon footprint (e.g., the new Italian minimum environmental criteria Decree). A further highlight is planned with respect to renewable materials such as vegetable oils, resins, biomass residues and fibers (natural or recycled), which can reasonably imply the development of innovative performance analysis and characterization protocols to be coupled with the traditional assessment techniques (unconventional rheological analysis, thermal assessment, advanced chemical evaluation, long-term monitoring, durability analysis, etc.). Together with the focus on the use of pure materials, particular attention can be given to specific aspects related to efficient and sustainable construction technologies, as well as to the maintenance and repair of structures, pavements, and foundations. These include warm technologies, in-situ and cold recycling, surface treatments, and innovative coatings. As a summary, the activity addresses a comprehensive overview of the transition toward sustainable infrastructures through the use of green materials, fostering innovation in design, maintenance, and management of resilient, circular, and low-carbon transport infrastructures.

Proposed Lectures	1) **Road materials and technologies to mitigate the environmental impacts in urban area** (2 hours) by **Andrea Baliello (Università di Padova)**

General Topic	Life Cycle Assessment (LCA) and Sustainability in Transportation Infrastructures

Short description	The topic "LCA and Sustainability in Transportation Infrastructures" focuses on the assessment, design, and optimization of sustainable materials and technologies for road and railway construction, maintenance, and rehabilitation. The main goal is to promote a life-cycle thinking approach in civil engineering, integrating environmental, social, and economic dimensions into infrastructure planning and management.
	The seminars will explore the use of Life Cycle Assessment (LCA) and Life Cycle Cost Analysis (LCCA) methodologies to quantify the environmental impacts and long-term performance of traditional and innovative materials — including recycled aggregates, reclaimed asphalt, and recycled plastics — used in pavement and structural applications. The potential of local resources, experimental validation, and predictive performance modeling will also be discussed to ensure sustainable design and resource efficiency. Additional sessions may address advanced pavement technologies such as energy-harvesting systems (e.g., hybrid photovoltaic pavements, piezoelectric surfaces) and cool pavements for mitigating urban heat islands. The evaluation of these solutions will highlight their contribution to sustainability and resilience in transportation networks.
	A further topic of interest concerns the development of common frameworks for sustainability assessment, combining LCA with quantitative indicators of safety, durability, and social impact. Case studies will include the application of LCA to compare traditional and alternative materials, evaluate rehabilitation strategies, and identify critical stages within infrastructure life cycles. Overall, the seminars aim to provide doctoral students with theoretical and practical tools to integrate sustainability principles into the design and management of transportation infrastructures, fostering innovation and compliance with the evolving environmental regulations and "Green Public Procurement" (e.g., CAM Strade).

Proposed Lectures	1) **Life Cycle Assessment for Sustainable Road Infrastructures** (2 hours) by **Giulia Del Serrone (Sapienza Università di Roma)**

General Topic	Smart Infrastructures

Short description	Smart Infrastructures are a set of constructions equipped with advanced technology that allows for the collection and sharing of real-time data. In the field of road infrastructures, this concept is directly related to "Smart Road" technology. The roads are gradually transforming into smart ones thanks to a digital transformation process aimed at introducing traffic and monitoring platforms, data and information processing models, advanced services for infrastructure managers, and the creation of a technological ecosystem in favour of interoperability between infrastructures and new-generation vehicles. The main goals of this change are related to road safety, traffic management, information to road users, and road network resilience and management. Smart Roads are mandatory for the introduction of Connected and Autonomous Vehicles (CAVs). The combination of Smart Roads and CAVs should improve road safety in the context of the VisionZero goal. Their integration is essential for maximizing the benefits of these smart infrastructures. One possible future enhancement of smart roads can be to monitor road conditions and plan maintenance procedures through the collected data from on-board sensors (equipped vehicles) and road-side ones. The collection of these parameters could support both predictive and reactive maintenance, localising deterioration and targeting the intervention. The other key aspect of Smart Roads is road safety, which can be analysed through the behaviour of drivers operating CAVs. The transition from traditional vehicles to autonomous vehicles is a crucial theme in this research field. To mitigate the effects of this transition, the study of the impacts of Advanced Driver Assistance Systems (ADAS) on the drivers is crucial. This research can be conducted both in a simulated environment and in a real context. The data can be collected through wearable sensors and webcams to record both the driving performance and physiological parameters of drivers. Recorded data are synchronized with specific events during the tests, such as unexpected objects on road, obstacles or the activation of some ADAS, to evaluate the drivers' reaction.

Proposed Lectures	1) **Smart Technologies for the Safety and Maintenance of Road Infrastructures** (2 hours) by **Alessia Ruggeri (Università di Messina)**

General Topic	Railways

Short description	The "Railways" topic covers a wide range of research and application fields related to the design, construction, management, and operation of railway infrastructures and systems. It includes both traditional and innovative approaches to the study of railway components, performance, and sustainability. The topic has strong interconnections with others, such as smart infrastructures, GIS/BIM, monitoring systems, sustainability, and transport safety. Research in this area can be divided into several key fields.
	The first is infrastructure engineering, which includes the study, design, and maintenance of the railway track, substructure (formation layer, i.e., the prepared foundation of the track, sub-ballast, and ballast), and superstructure (rails, sleepers, fastenings, joints). Topics of interest involve the mechanical behavior of track components and their structural dimensioning, long welded rails, track geometry degradation, and the development of approaches for performance prediction and maintenance planning. Studies on track geometry also focus on alignment optimization and transition curve design, aimed at improving safety, comfort, and interoperability.
	A second domain is railway systems and operations, which focuses on capacity, signaling, train control systems (e.g., ERTMS/ETCS) and traffic management. Simulation models and optimization tools can be used to study the interaction between infrastructure, rolling stock, and service planning, with particular attention to punctuality, reliability, and resilience of railway networks.
	The third area is diagnostic and monitoring systems, focusing on the development, application, and optimization of advanced measurement and sensing technologies. Studies include ground-based systems, on-board instrumentation, and satellite-based techniques, enabling continuous monitoring of railway track conditions. The integration of intelligent sensors, data analytics, and predictive maintenance tools, including machine learning approaches, supports a modern, data-driven management of railway infrastructure.
	Another emerging area is innovation and sustainability in railways, which focuses on the study and adoption of innovative materials for railway infrastructures, including rails, sleepers, fastenings, and ballast. Research also investigates materials performance, durability, and interaction with track components, aiming to improve infrastructure service life, reduce maintenance needs, and enhance operational safety. This also covers the environmental and socio-economic assessment of railway infrastructures, modal shift promotion, and integration within smart mobility systems.
	Finally, safety and human factors are cross-cutting themes involving risk analysis and human behavior in railway operations. The adoption of digital twins, virtual and augmented reality, and BIM-based tools can support both safety assessment and training activities.

Proposed Lectures	1) **Railway engineering: safety and sustainability** (2 hours) by **Stefano Coropulis (Politecnico di Bari)**

General Topic	Airports

Short description	This seminar aims to provide a first understanding of the management and operational aspects of airports, focusing on key topics essential for the efficiency and safety of the entire airport system. While technical aspects related to the design of airports are covered in Master's degree programs, this course will explore vital concepts for the management of airport infrastructure. 1. Airport safety and efficiency: a systematic perspective: This section examines the key stakeholders involved in the airport system, including national and international regulatory authorities. It will provide an overview of the regulatory frameworks governing airport operations, with a particular focus on ICAO, EASA and ENAC regulations and standards. It will also cover best practices for ensuring the proper development and management of airport infrastructure. The importance of human behavior in the airport context will be also explored. It will cover the key human factors that influence the safety and efficiency of airport operations, such as communication between staff members, stress management, and ongoing training. The goal is to equip civil engineers with tools to understand and enhance the interactions between people, technology and complex systems within airport operations. 2. Management of Airport paved assets This section will provide students with key information regarding the most applied international standards, used technologies, recognized indexes and common practices concerning the Airport Pavement Management Systems. Furtherly, this section will explore innovative research frontiers in the monitoring phase included into the APMS, which aim at depicting the health condition of a paved area within an Airport.

Proposed Lectures	1) **Regulation, Safety and Human Performance in Airport Engineering and Operations** (2 hours) by **Alberto Portera (ENAC)** 2) **From big data to smart decisions: innovative tools for airport pavement management** (2 hours) by **Luca Bianchini Ciampoli (Università Roma Tre)**

Lectures Timetable – Tentative (2026)

The following timetable outlines the tentative schedule of the lecture's series, organized by macro-themes and distributed over multiple academic periods. Dates marked as "to be defined" indicate lectures whose scheduling will be finalized at a later stage. This timetable is intended as a planning and communication tool, and minor adjustments may occur.

Macro theme	Lecture title	Speaker	Tentative date
Road Safety	Road safety advances from a safe system approach perspective	Paolo Intini (Università del Salento)	24/03/2026
	Assessing Human Performance in Driving through Innovative Technologies	Margherita Pazzini (Università di Bologna)	26/03/2026
Monitoring and Remote Sensing	Monitoring Techniques and Advanced Remote Sensing for Infrastructure Resilience	Valerio Gagliardi (Università Roma Tre)	08/04/2026
	Multi-Source Data Integration for Infrastructure Monitoring: UAV Surveys and the Digital Twin Frontier	Valerio Gagliardi (Università Roma Tre)	15/04/2026
ML / AI / Big Data / FCD	Predictive Modeling of Road User Behavior using FCD	Giulia Del Serrone (Sapienza Università di Roma)	12/05/2026
BIM / GIS	BIM and GIS for Infrastructure: Toward an Integrated Digital Twin	Salvatore Antonio Biancardo (Università di Napoli Federico II)	19/05/2026
	Parametric BIM Design using Visual Programming Language	Mattia Intignano (Università di Napoli Federico II)	26/05/2026
	I-BIM approaches for road design and maintenance management	Giuseppe Sollazzo (Università di Messina)	10/06/2026
Innovative Materials	Self-sensing asphalt composite with carbon microfibers for smart weigh-in-motion	Alessandro Corradini (Università di Perugia)	24/06/2026
Green Materials	Road materials and technologies to mitigate the environmental impacts in urban area	Andrea Baliello (Università di Padova)	30/06/2026
LCA / Sustainability	Life Cycle Assessment for Sustainable Road Infrastructures	Giulia Del Serrone (Sapienza Università di Roma)	11/09/2026

Macro theme	Lecture title	Speaker	Tentative date
Smart Infrastructures	Smart Technologies for the Safety and Maintenance of Road Infrastructures	Alessia Ruggeri (Università di Messina)	22/09/2026
Railways	Railway engineering: safety and sustainability	Stefano Coropulis (Politecnico di Bari)	29/09/2026
Airports	Regulation, Safety and Human Performance in Airport Engineering and Operations	Alberto Portera (ENAC)	22/10/2026
	From big data to smart decisions: innovative tools for airport pavement management	Luca Bianchini Ciampoli (Università Roma Tre)	