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04

THE CURRENT STATUS OF AUTONOMOUS VEHICLE TECHNOLOGY ADOPTION IN THE BALKAN REGION

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Abstract

The development of autonomous vehicles in the Balkan region remains highly uneven, reflecting differences not only in legislation and infrastructure but also in the underlying digital and information-technology capabilities required for advanced autonomous systems. This paper provides a comparative analysis of IT-driven autonomous vehicles readiness across Serbia, Croatia, Bosnia and Herzegovina, Montenegro, Albania and North Macedonia. Serbia has taken a good regional position by enabling public-road autonomous vehicles testing supported by a regulatory framework that specifies requirements for onboard sensor suites, data-logging modules, AI-based perception algorithms, and remote supervision systems. Croatia is advancing through research initiatives focused on machine-learning pipelines for environment perception, simulations for autonomous navigation, and early-stage V2X communication testing, including preparations for Level-4 robotaxi deployments. In contrast, Bosnia and Herzegovina, Montenegro, Albania and North Macedonia exhibit early-stage readiness, with limited ICT infrastructure, no autonomous vehicles testbeds, and ongoing challenges related to digital mapping quality, inconsistent road-sensor integration, and limited high-accuracy geospatial datasets needed for autonomous operation. Despite these limitations, all four states are gradually expanding smart-city architectures, intelligent

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traffic management platforms, and EU-funded research collaborations that could support future autonomous vehicles deployment. The findings highlight that the region's trajectory toward autonomous mobility will depend heavily on the expansion of high-resolution mapping, V2X communication standards, 5G/edge-computing availability, secure data-exchange protocols, and reliable AI-model governance frameworks.

Keywords: autonomous vehicles, regulatory framework, digital infrastructure

I. INTRODUCTION

Autonomous vehicle (AV) technology is widely recognized as a cornerstone of future intelligent transportation systems, with the potential to significantly improve road safety, traffic efficiency, environmental performance, and accessibility of mobility services. Rapid advances in artificial intelligence (AI), sensor technologies, high-performance computing, and digital connectivity have enabled vehicles to perceive complex environments, make real-time decisions, and interact with surrounding infrastructure (Sedat et al., 2024). These capabilities have accelerated the transition from experimental prototypes to pilot deployments and early commercial services, particularly in technologically advanced regions.

Despite this progress, the adoption of autonomous vehicle technology remains highly uneven across Europe. While countries such as Germany, France, and the Nordic states have established comprehensive regulatory frameworks and invested heavily in digital infrastructure, many regions continue to face substantial technological and institutional barriers. Among these, the Balkan region represents a particularly diverse and underexplored context. Historical differences in economic development, infrastructure investment, and digital transformation have resulted in significant disparities in readiness for advanced mobility technologies.

Autonomous vehicles are inherently information-technology-intensive systems. Their safe and reliable operation depends not only on vehicle hardware but also on the availability of robust digital infrastructure, including high-bandwidth communication networks, edge and cloud computing resources, high-resolution digital maps, and large-scale datasets for AI model training and validation (Garikapati & Shetiya, 2024). In addition, autonomous systems require secure and transparent data governance frameworks to ensure accountability, cybersecurity, and public trust. Consequently, assessing AV readiness solely through legislative or policy indicators provides an incomplete picture of actual deployment potential.

In the Balkan region, several countries have begun to recognize the strategic importance of autonomous mobility, either through regulatory initiatives or research-oriented projects. However, the pace and nature of progress vary considerably. Some states have enabled controlled testing of

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autonomous vehicles on public roads, while others remain focused on basic intelligent transport systems and digital traffic management. These differences raise important questions regarding the region's overall trajectory toward autonomous mobility and the feasibility of cross-border autonomous transport in the future.

The goal of this paper is to provide a comprehensive assessment of the current status of autonomous vehicle technology adoption in the Balkan region, with a specific focus on the underlying information-technology foundations. The analysis covers six countries: Serbia, Croatia, Bosnia and Herzegovina, Montenegro, Albania, and North Macedonia, and evaluates their readiness across multiple technological dimensions, including digital infrastructure, AI and data ecosystems, autonomous vehicle testing environments, digital mapping quality, and intelligent transport systems. By systematically comparing these dimensions, the paper aims to identify key disparities, common bottlenecks, and potential enablers that will shape the future of autonomous mobility in the region.

II. METHODS

This study employs a qualitative comparative research design to analyze autonomous vehicle technology adoption across selected Balkan countries. The chosen methodology is appropriate given the early developmental stage of autonomous vehicle deployment in the region and the limited availability of standardized quantitative indicators. Rather than focusing on market penetration or fleet size, the analysis emphasizes technology readiness, which reflects the structural capacity of a country to support autonomous vehicle systems.

The comparative approach enables the identification of relative strengths and weaknesses across countries while accounting for contextual differences in economic scale, transport demand, and institutional structure. Each country is evaluated using a consistent set of criteria, allowing for systematic comparison and synthesis of results.

II.1. Evaluation dimensions

To capture the multidimensional nature of autonomous vehicle readiness, the analysis is structured around five interrelated evaluation dimensions:

- Digital and communication infrastructure: This dimension assesses the availability, reliability, and performance of digital connectivity essential for autonomous vehicle operation. Key elements include fixed and mobile broadband coverage, the deployment status of fifth-generation (5G) mobile networks, and access to cloud and edge-computing

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infrastructure. These components are critical for real-time data transmission, cooperative perception, and remote monitoring of autonomous vehicles.

- Autonomous vehicle testing and validation environment: This dimension examines whether countries provide legal and technical conditions for testing autonomous vehicles. It includes the existence of regulatory frameworks permitting public-road testing, technical specifications for onboard sensors and data-logging systems, and the availability of physical or virtual test environments. Testing and validation are essential for transitioning from laboratory research to real-world deployment.
- AI and data ecosystem: Autonomous driving relies heavily on AI-based perception, prediction, and decision-making systems. This dimension evaluates the maturity of machine-learning pipelines, availability of training and validation datasets, use of simulation platforms, and mechanisms for model evaluation and update. The presence of research institutions and industry actors engaged in AI development is also considered.
- Digital mapping and geospatial data: Accurate localization and navigation require high-definition (HD) digital maps and precise geospatial data. This dimension assesses the availability of HD mapping, satellite positioning accuracy, and correction services such as real-time kinematic systems. Deficiencies in mapping quality can significantly limit autonomous vehicle functionality.
- Intelligent transport systems and V2X communication: This dimension considers the deployment of intelligent transport systems (ITS), including traffic sensors, adaptive signaling, and data platforms. It also evaluates early-stage vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communication initiatives, which are increasingly important for cooperative and connected autonomous driving.

II.2 Data collection and sources

To ensure the comparative analysis is grounded in verified policy documents, technological roadmaps, and internationally recognized frameworks, this study synthesizes information from a variety of authoritative sources. These encompass regional regulatory texts, European Union policy frameworks, international standards, and transport-community monitoring reports. The sources reflect both formal regulatory context and implementation-level technology indicators relevant for autonomous vehicle adoption.

The European Union has developed several high-level strategic documents that shape autonomous vehicle technology adoption, including digital readiness, AI governance, and connectivity standards. These documents provide regional context that is especially relevant for countries aspiring to align with EU norms:

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- Connected and automated mobility (CAM) policy: The European Commission's CAM framework promotes the integration of autonomous systems with intelligent transport networks, underscoring those digital technologies (including AI, secure connectivity, and data governance) are critical enablers for autonomous mobility. This policy situates autonomous driving within broader transport and digital strategies, emphasizing interoperability, cybersecurity, and spectrum/connectivity requirements[1].
- European connected and autonomous vehicle alliance (ECAVA[2]): As part of the EU's industrial action plan, ECAVA was established to coordinate industry and policy actions on software defined vehicles, AI models, and large-scale autonomous driving pilots. It represents the EU's commitment to fostering collaborative innovation ecosystems for autonomous and connected vehicles.
- Automated driving corridors and harmonized permitting: Recent EU proposals include the development of automated driving corridors and harmonized permitting procedures for public-road autonomous vehicle testing. These initiatives aim to reduce regulatory fragmentation and enable cross-border testing environments (EU, 2025).
- 5G strategic deployment agenda for connected and automated mobility: Released by the Smart Networks & Services Joint Undertaking (SNS JU), this agenda outlines deployment strategies for 5G networks specifically tailored to support connected and autonomous mobility along European transport corridors, including uninterrupted coverage across borders (6GSNS, 2026).

Together, these EU documents provide a normative baseline for digital infrastructure, AI governance, and regulatory harmonization that Balkan countries may reference or diverge from in their own autonomous mobility efforts.

The Western Balkans Transport community has produced monitoring reports that document progress in digitalization and connected mobility across Southeast Europe. These include information on ITS, traffic control centers, and interoperable tolling systems, which are building blocks for future autonomous vehicle ecosystems. From this point of view sustainable and smart mobility strategy monitoring report is most important. This report tracks regional developments in ITS deployment, digital traffic management platforms, and interoperability initiatives among transport community member countries. These indicators help assess the regional baseline for connected infrastructure that could support autonomous driving technologies (Transport Community, 2024).

[1] Connected and automated mobility, https://digital-strategy.ec.europa.eu/en/policies/connected-and-automated-mobility

[2] European Connected and Autonomous Vehicle Alliance (ECAVA), https://digitalstrategy.ec.europa.eu/en/policies/vehicle-alliance

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These regional insights are particularly valuable when national autonomous vehicle strategies are absent or incomplete, allowing indirect assessment through proxy indicators such as smart mobility investment and interoperability achievements.

In addition to policy sources, academic and technical research on autonomous systems informs the study's understanding of essential technological components, for example:

- ICT reference architectures for automated driving: Technical studies on the role of information and communication technologies provide reference architectures for autonomous systems, highlighting the importance of network infrastructure, data flows, and communication layers that support perception and decision-making (Buchholz et al., 2020).
- AI safety, transparency, and robustness in autonomous systems: Research on testing autonomous vehicles and AI examines key challenges related to cybersecurity, fairness, robustness, and transparency. These are factors that underpin trustworthiness and public acceptance of AV technologies (Llorca et al., 2025).

Global agreements and standards also influence national regulatory adaptations. For example:

- UNECE GRVA framework and regulations: The United Nations Economic Commission for Europe's Working Party on Automated/Autonomous and Connected Vehicles has developed regulations (such as UN R155 on cybersecurity and R157 on automated driving systems) that are widely referenced in national autonomous vehicle legislation due to their safety and interoperability emphasis[3].

These regulations shape national policy choices in Europe and serve as reference frameworks for countries seeking alignment with internationally recognized safety and data governance protocols.

The methodological design is constrained by the limited availability of standardized and comparable quantitative indicators related to autonomous vehicle technology adoption in the Balkan region. Metrics such as autonomous vehicle testing mileage, extent of high-definition mapping coverage, density of V2X-enabled infrastructure, or validated AI system performance are not consistently reported or are absent across national contexts. As a result, the study does not apply quantitative scoring or statistical comparison methods. Instead, the analysis relies on qualitative assessment of documented regulatory measures, infrastructure deployment status, and technological initiatives to identify relative readiness patterns and structural differences among countries.

[3] https://unece.org/artificial-intelligence

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III. RESULTS

1. Serbia

Serbia demonstrates the most advanced level of autonomous vehicle technology readiness among the analyzed Balkan countries. A notable achievement is the establishment of a regulatory framework that permits autonomous vehicle testing on public roads under defined technical conditions[4]. These conditions include requirements for onboard sensor suites, such as cameras, radar, and LiDAR, as well as continuous data logging and remote supervision capabilities. From an IT perspective, Serbia has made progress in aligning regulatory provisions with technical realities. The requirement for AI-based perception systems and data recording indicates recognition of the importance of transparency, traceability, and post-event analysis. Furthermore, the presence of academic and research institutions engaged in AI and robotics supports experimental development and workforce capacity building. However, challenges remain. Large-scale availability of high-resolution digital maps and nationwide 5G coverage is still limited, which constrains broader deployment beyond controlled testing environments. Despite these limitations, Serbia has established a solid foundation for further advancement.

2. Croatia

Croatia's approach to autonomous vehicle development is primarily research-driven. The country has invested in machine-learning pipelines for environment perception, advanced simulation environments for autonomous navigation, and early-stage testing of V2X communication technologies. These efforts are supported by a strong innovation ecosystem and participation in international research collaborations. Preparations for Level-4 autonomous systems, particularly in urban contexts such as robotaxi concepts, distinguish Croatia within the region (Milenkovic et al., 2025). Simulation-based testing plays a central role, allowing for large-scale scenario evaluation without the risks associated with real-world deployment. Nevertheless, the transition from research prototypes to sustained public-road operation remains a key challenge, particularly in terms of regulatory harmonization and infrastructure scaling.

3. Bosnia and Herzegovina

Bosnia and Herzegovina exhibits limited readiness for autonomous vehicle technology adoption. The country lacks dedicated regulatory provisions for autonomous vehicle testing and does not

[4] Law on Traffic Safety and Roads, Official Gazette of Republic of Serbia, no. 41/2009, 53/2010, 101/2011, 32/2013 – decision CC, 55/2014, 96/2015, 9/2016 – decision CC, 24/2018, 41/2018, 41/2018, 87/2018, 23/2019, 128/2020, 76/2023 and 19/2025)

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provide structured test environments. ICT infrastructure development is uneven, and intelligent transport systems are fragmented across administrative entities. Digital mapping quality and access to high-accuracy geospatial data are insufficient for autonomous navigation, particularly outside major urban areas. While there are isolated initiatives related to traffic monitoring and digitalization, these efforts remain disconnected from autonomous vehicle requirements.

4. Montenegro

Montenegro has initiated several smart-city and intelligent traffic management projects, especially in urban and tourist areas. These initiatives focus primarily on traffic optimization and congestion management rather than autonomous vehicle deployment. Although improvements in digital connectivity are ongoing, the absence of HD mapping, V2X integration, and AV testing frameworks limits readiness. Current developments may serve as a foundation for future autonomous mobility, but substantial additional investment and strategic alignment are required to bridge the gap between conventional ITS and autonomous systems.

5. Albania

Albania is undergoing broader infrastructure modernization, including upgrades to road networks and digital connectivity. However, autonomous vehicle-specific technologies remain largely absent. AI and data ecosystems relevant to autonomous driving are underdeveloped, and there are no formal testing or validation frameworks. The country's progress is currently concentrated on establishing baseline ICT capabilities, which could support future autonomous vehicle initiatives if complemented by targeted investments in mapping, data governance, and research capacity.

6. North Macedonia

North Macedonia has introduced elements of intelligent transport systems and digital traffic monitoring, primarily aimed at improving road safety and efficiency. Nevertheless, autonomous vehicle readiness remains low. AI development related to autonomous driving is limited, and there is no structured framework for testing or validation. As with other early-stage countries, progress toward autonomous mobility depends largely on broader digital transformation efforts rather than dedicated AV strategies.

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7. Comparative summary of autonomous vehicle technology readiness in the Balkan region

The comparative analysis of the six Balkan countries reveals pronounced asymmetries in autonomous vehicle technology readiness, reflecting broader differences in digital maturity, institutional capacity, and innovation ecosystems. Rather than forming a linear progression, the region is best described as a multi-tier readiness landscape, where countries cluster into distinct groups based on the alignment between regulatory initiatives, digital infrastructure, and applied research capacity. Comparative overview is presented in Table 1.

As can be seen from Table 1, Serbia and Croatia demonstrate partial but tangible alignment with the technical requirements of autonomous vehicle systems. Serbia's strength lies primarily in its regulatory technical integration, as it has established formal conditions for autonomous vehicle testing on public roads that explicitly reference IT components such as sensor redundancy, AI-based perception systems, data logging, and remote supervision (National AI Platform, 2023). This indicates institutional awareness of the operational complexity of autonomous vehicles and the need for traceable, auditable system behavior. However, Serbia's readiness remains constrained by uneven availability of high-resolution digital maps, limited nationwide 5G coverage, and the absence of large-scale V2X deployments, which collectively restrict scalability beyond controlled test scenarios.

Croatia, by contrast, exhibits a research-centric readiness profile, characterized by advanced work on machine-learning pipelines, simulation-based validation environments, and early experimentation with V2X communication technologies. These capabilities support the development and testing of higher-level autonomous functions, particularly in structured urban contexts. Croatia's focus on Level-4 autonomy concepts, such as robotaxi deployments, places it at the forefront of regional innovation (Milenkovic et al., 2025). Nevertheless, the reliance on research and pilot environments underscores a gap between experimental maturity and widespread operational readiness, especially in terms of regulatory harmonization and infrastructure rollout.

A second cluster, comprising Bosnia and Herzegovina, Montenegro, Albania, and North Macedonia is characterized by early-stage readiness, where foundational elements of autonomous vehicle technology ecosystems remain underdeveloped or fragmented. In these countries, efforts are largely concentrated on conventional intelligent transport systems, such as traffic monitoring, adaptive signaling, and basic smart-city platforms. While these initiatives contribute indirectly to autonomous vehicle preparedness, they do not yet address the stringent requirements of autonomous operation, including high-precision localization, continuous vehicle–infrastructure communication, and large-scale AI model validation.

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Table 1. Comparative overview of autonomous vehicle technology readiness in the Balkan region.

Country	AV testing framework	Digital infrastructure	AI & data ecosystem	HD maps	ITS / V2X	Readiness
Serbia	Yes	Medium	Medium	Limited	Early	Moderate
Croatia	Partial	Medium–High	High (research)	Partial	Early	Moderate
Bosnia and Herzegovina	No	Low-Medium	Low	Insufficient	Fragmented	Low
Montenegro	No	Medium	Low	Absent	ITS-focused	Low
Albania	No	Medium	Low	Limited	Basic	Low
North Macedonia	No	Medium	Low	Insufficient	Basic	Low

Across this second cluster, deficiencies in digital mapping quality and geospatial data availability emerge as a critical limiting factor. Autonomous vehicles require centimeter-level localization accuracy and frequent map updates to operate safely, particularly in complex urban or mixed-traffic environments. The absence of such capabilities significantly constrains autonomous functionality, even in the presence of improving connectivity or traffic management systems. Furthermore, limited access to high-quality datasets and simulation platforms restricts the development and validation of AI models tailored to local road conditions, signage, and traffic behavior.

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From a regional perspective, one of the most significant findings is the lack of interoperability and harmonization across national borders. Autonomous vehicle operation, especially in regions with dense cross-border traffic flows, depends on compatible digital infrastructure, standardized V2X protocols, and aligned data-governance frameworks. The current fragmentation of standards, combined with uneven ICT deployment, suggests that cross-border autonomous mobility in the Balkans remains a long-term prospect rather than an imminent reality.

Despite these challenges, the comparative results also reveal shared enabling factors that could support future convergence. All analyzed countries are engaged, to varying degrees, in digital transformation initiatives and participate in European Union–funded research and infrastructure programs. These initiatives provide access to technical expertise, funding mechanisms, and harmonized frameworks that could accelerate autonomous vehicle readiness if strategically aligned with national priorities. In particular, regional cooperation on high-definition mapping, shared testing corridors, and coordinated V2X deployment could mitigate resource constraints and reduce duplication of effort.

In summary, the comparative analysis indicates that autonomous vehicle technology adoption in the Balkan region is not constrained by a lack of interest or strategic intent, but rather by uneven development of the underlying information-technology ecosystem. While Serbia and Croatia demonstrate emerging leadership roles, the broader region remains in a preparatory phase, where targeted investments in digital infrastructure, AI ecosystems, and cross-border interoperability will be decisive for future progress. This stratified readiness landscape underscores the need for coordinated regional approaches that move beyond isolated national initiatives toward a shared vision of autonomous mobility.

IV. CONCLUSION

This paper presented a comparative assessment of autonomous vehicle technology adoption in the Balkan region, focusing on the information-technology foundations required for autonomous operation. The analysis of Serbia, Croatia, Bosnia and Herzegovina, Montenegro, Albania, and North Macedonia revealed substantial disparities in readiness, driven primarily by differences in digital infrastructure, AI and data ecosystems, and intelligent transport systems.

Serbia and Croatia emerge as relative regional leaders, though through different development paths. Serbia has enabled public-road testing of autonomous vehicles through regulatory and technical alignment, while Croatia's progress is driven by research-oriented initiatives, simulation-based validation, and early V2X experimentation. Nevertheless, both countries face limitations related to large-scale deployment, particularly in high-resolution digital mapping, nationwide connectivity, and interoperable communication systems. The remaining countries are at an early

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stage of adoption, with progress largely confined to conventional ITS and smart-city projects that do not yet meet the requirements of autonomous vehicle operation.

A key conclusion is that information-technology readiness, rather than legislative intent alone, represents the main constraint on autonomous vehicle deployment in the Balkan region. Fragmented digital infrastructure, limited data availability, and insufficient AI validation frameworks significantly restrict scalability and cross-border interoperability. While EU-funded projects and regional digital initiatives provide important enabling conditions, coordinated investment in digital connectivity, geospatial data, and governance frameworks will be essential for future progress. Further research should focus on quantitative readiness assessment and empirical evaluation of pilot deployments to support evidence-based autonomous mobility strategies in the region.

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REFERENCES

6GSNS. (2026). *5G Strategic Deployment Agenda for Connected and Automated Mobility*. https://smart-networks.europa.eu/wp-content/uploads/2026/01/sns_5g_sda_for_cam_on_road.pdf

Buchholz, M., Strohbeck, J., Adaktylos, A.M., Vogl, F., Allmer, G., Barros, S. C., Lassoued, Y., Wimmer, M., Hätty, B., Massot, G., Ponchel, C., Bretin, M., Sourlas, V., & Amditis, A. (2020). Enabling Automated Driving by ICT Infrastructure: A Reference Architecture. *Proceedings of 8th Transport Research Arena TRA 2020*, April 27-30, Helsinki, Finland. https://arxiv.org/pdf/2003.05229

European Commission, *Questions and Answers on the Commission Unveiling the Action Plan to Drive Innovation, Sustainability, and Competitiveness in the Automotive Sector*. https://ec.europa.eu/commission/presscorner/api/files/document/print/en/qanda_25_636/QANDA_25_636_EN.pdf

Garikapati, D., & Shetiya S.S. (2024). Autonomous Vehicles: Evolution of Artificial Intelligence and the Current Industry Landscape. *Big Data and Cognitive Computing*, 8(4), 42-67.

Llorca, D.F., Hamon, R., Junklewitz, H., Grosse, K., Kunze, L., Seiniger, P., Swaim, R., Reed, N., Alahi, A., Gómez, E., Sánchez, I., & Kriston, A. (2025). Testing Autonomous Vehicles and AI:

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Perspectives and Challenges from Cybersecurity, Transparency, Robustness and Fairness. *European Transport Research Review, 17*(38), https://doi.org/10.1186/s12544-025-00732-x

Milenkovic, M., Sumpor, D., & Tokic, S. (2025). Legal and Safety Aspects of the Application of Automated and Autonomous Vehicles in the Republic of Croatia. *World Electric Vehicle Journal, 16*(34), https://doi.org/10.3390/wevj16010034

National AI Platform, (2023). *Serbia Joins the Ranks of Early Adopters Testing Self-Driving Cars on Its Roads.* https://www.ai.gov.rs/vest/en/525/serbia-joins-the-ranks-of-early-adopters-testing-self-driving-cars-on-its-roads.php

Sonko, S., Augustine E. E., Ibekwe, K. I. Ilojianya, V.I., & Daudu C.D. (2024). A Comprehensive Review of Embedded Systems in Autonomous Vehicles: Trends, Challenges, and Future Directions. *World Journal of Advanced Research and Reviews, 21*(01), 2009-2020.

Transport Community. (2024). *Sustainable and Smart Mobility Strategy in the Western Balkans – Progress Report.* https://www.transport-community.org/wp-content/uploads/2024/12/2024-Sustainable-and-Smart-Mobility-Strategy-monitoring-report.pdf

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International conference on sustainable mobility

Agenda

Project title: International Engineering Competence Centres to push Sustainable Mobility Development in Albania and Montenegro
Acronym: INTEC

Work package	
WP11	**International conference**
TASK	
11.4	Coummunity Building Events

Dates	05.03.-06.03.2026
City	Tirana
Meeting venue	POLIS University Entrance Hall
Address	Rr. Bylis 12, Kodi Postar 1051, Kutia Postare 2995, Tirana, Albania

05.03.2026	
Entrance Hall, POLIS University	
8:30 – 9:00	**Registration**
9:00 – 9:30	**Opening Performance**
Welcome session – Auditorium A5 (Ground floor)	
9:30 – 10:00	**Opening Remarks** **Dr. Elona Karafili** (Vice Rector, POLIS University) **Dr. Flora Krasniqi** (Head of Office of Projects and Internationalization, POLIS University) **DI Daniela Wenzl** (INTEC Project Coordinator)
Auditorium A5 (Ground floor)	
10:00 –11:00	**Keynote speakers** **DI Horst Pflügl AVL** Collaborative Research for sustainable Mobility **DPSHTRR Representative** – (General Directorate of Road Transport Services in Albania)
11:15 – 11:30	**Coffee break (Moving into parallel sessions)**

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11:30	SESSION 1: POLITICAL AND REGULATORY FRAMEWORK AULA B1	SESSION 2: TECHNOLOGICAL INNOVATION AULA B4
11:30 – 11:45	**Opening Session:** Prof. Emeritus dr Nataša Gospić (FSKL)	**Opening Session:** Associate Prof. Ivan Tolj (US)
11:45 – 12:00	**Integrating Event Data Recorder (EDR) Technology into Sustainable Road Safety Frameworks within the European Green Deal** Eriselda Alimeti, Parid Milo, Mentor Çejku, Anis Sulejmani, Odhisea Koça	**Empirical Comparative Study of Structural CFRP Sandwich Structure Inserts for Out-of-Plane loads** Imre Kovács
12:00 – 12:15	**Infrastructure Readiness for Sustainable Mobility: EU Frameworks and the Case of Albania** Ervin Kalemaj, Parid Milo, Mentor Çejku, Anis Sulejmani, Odhisea Koça	**The Role of Intermodal Transportation for the Sustainable Mobility** Márton Kovács
12:15 – 12:30	**Review of the Evolution of International Ship Energy Efficiency Regulations and the Albanian context** Dr. Blenard Xhaferaj, Doklejda Hodaj	**Impact of Heat Pump Systems on Winter Energy Use and Driving Range in Battery Electric Vehicles** Luis Henrique Pereira Martins
12:30 – 12:45	**Renewable Energy Procurement (CPPA) and Transport Electrification: European Perspectives and Albanian Challenge** Antonio Ndoci, Anis Sulejmani, Odhisea Koça, Mentor Çejku, Parid Milo	**Liquid Cooling Systems for Electric Vehicle Batteries: Improving Safety, Performance and Sustainability** João Miguel de Almeida Ribeiro Silva
12:45 – 13:00	**The Current Status of Autonomous Vehicle**	**Analysis of Battery Charging and Discharging Behavior for Electric Vehicle Applications** Leona Markic, Luka Filipović

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	Technology Adoption in the Balkan Region Darjana Lopičić, Oliver Popović, Miloš Ilić, Bojan Kocić	
13:00 – 14:00	**Lunch**	
14:00 – 14:15	**Reviewing the European Green Deal in Energy, Mobility and Industry** Veselinka Calasan, Ivana Ognjanovic	**Automotive Cooling Systems Sustainability: A Focus on the Expansion Tank** Ana Inês Barbeiro Casimiro
14:15 – 14:30	**The European Green Deal and its National Implementation: From Strategy to Practice** Blerina Bektashi, Andi Bektashi	**Design and Development of a Constant-Volume Combustion Chamber for Optical Investigation of Hydrogen and Water Injection Under Engine-like Conditions** Julius Hollerith, Prof. Dr. Bhavin Kapadia
14:30 – 14:45	**From Prediction to Regulation: Evidence Production Approaches in Autonomous Mobility Research and Their Policy Implications** Sadmira Malaj	**Emission Reduction of Marine Propulsion Systems in SECA Zones Through the Integration of Hydrogen Technologies** Motalleb Miri, Ivan Radaš, Marija Mandić, Ivan Tolj
14:45 – 15:00	**Questions and Discussion**	**A Comprehensive Analysis of Ventilation System for Enhanced Energy Efficiency in Marine Propulsion Applications** Sara Blašković, Gojmir Radica, Jakov Šimunović

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15:00 – 15:15		**Design and Topology Optimization of a Lightweight Chain Sprocket for Electric Motorcycle Applications** Teo Čolović, Ivo Marinić-Kragić
15:15 – 15:30	**SESSION 3: ECONOMIC AND BUSINESS PRESPECTIVES + CASE STUDIES AND GOOD PRACTICES** Aula B1	**Questions and Discussion**
	Opening Session: Dr. Anis Sulejmani (PUT)	
15:30 – 15:45	**Managing Renewable Energy Resources as a Foundation for Sustainable Mobility Transitions** Deivi Sinanaliaj, Martin Bektashi	
15:45 – 16:00	**Feasibility of Electric Bus deployment in Montenegro: A Case Study of Budva (Erasmus+ INTEC / IECC Context)** Anastasija Mrkajic, Vinko Nikic.	
16:00 -16:15	**Children Paths as an Urban Regeneration Strategy: Naim Frasheri Study Case** Dejvi Dauti	
16:15 – 16:45	**Questions and Discussion**	

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Dates	05.03.-06.03.2026
City	Tirana
Meeting venue	POLIS University Entrance Hall
Address	Rr. Bylis 12, Kodi Postar 1051, Kutia Postare 2995, Tirana, Albania

06.03.2026		
First Floor Hall, POLIS University		
8:30 – 9:00	Registration	
9:00– 9:15	**SESSION 4: SOCIAL AND ENVIRONMENTAL IMPACT** AULA B1	**SESSION 5: FUTURE SCENARIOS** AULA B4
9:00 – 9:15	**Opening Session:** Prof. Dr. Bhavin Kapadia (FHF)	**Opening Session:** MA Adrian Millward-Sadler (FHJ)
9:15 – 9:30	**Comparison of Lifecycle Emissions of a SUV with Fuel Cell and Battery Electric Powertrains** - Bhavin Kapadia, Alper Sayin, Sandra Eisenträger	**GENAI Literacy as a Transversal Skill for Emerging Professionals: Implications for Sustainability-Critical Knowledge Work** – Adrian Millward-Sadler
9:30 – 9:45	**Smart Mobility Technologies and their Impact on Urban Sustainability: Insights from**	**Effects of Technical Traffic Calming Measures** – Filip Perović

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	European and Western Balkan Cities – Alma Gjonaj, Vjola Ziu	
9:45 – 10:00	**The Disappearing Squares: Social and Environmental Impacts of Urban Mobility Planning in Durres –** Arjola Sava	**Cybersecurity Vulnerabilities in Electric Vehicle Operating Systems: A Global Awareness Analysis -** Aleksa Radević
10:00 – 10:15	**The City that Demands Continuous Movement: The Disappearance of the Right not to Move within the Framework of Sustainable Mobility –** Avrili Meshi	**Development of a risk assessment model for the transport of hazardous materials using ALOHA and GIS software tools –** Marko Radetić
10:15 – 10:30	**Between Rhetoric and Reality: Discursive Framings, Greenwashing and Outcomes in Sustainable Mobility –** Kejsi Veselagu	**Mapping Distance and Time Leveraging Isochrone Intelligence in Emerging Cities** - Andia Vllamasi, Erjon Cobani
10:30 – 10:45	**Reimagining the City Through Green Mobility Strategies: The Case of Tirana** - Vjola Ziu, Alma Gjonaj	**Can AI develop its Own "Taste" Automotive Design?** - Gregor Andoni, Kristjana Meço
	Coffee Break	
11:00 – 11:15	**Linking Morphology, Perceived Safety, and Sustainable Mobility in Post-Socialist Urban Contexts-** Sindi Doce	**Optimizing Public Transport Corridors Using AI-Based Scenario Modelling: A case Study on Tirana's Ring Road** - Erjon Çobani, Julian Beqiri, Merita Guri
11:15 – 11:30	**Towards Sustainable Transport: A Comparative Analysis of Electric Vehicle Adoption in Montenegro and Albania -** Radmila Milić	**Threat Landscape and Multi-Layered Protection Mechanisms for Autonomous and Electric Vehicle Systems** - Marko Asanovic, Oliver Popović, Zoran Avramović, Nataša Gospić

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11:30 – 11:45	Questions and Discussion	**Cybersecurity Challenges in Modern Vehicular Communication Networks** - Aleksandar Grgurević, Nataša Gospić, Oliver Popović
11:45 – 12:00		**Green Transition in Albania: Challenges and Future Actions** - Erik Kushta, Andi Hyka, Enea Nasto
12:00 – 12:15	**SESSION 6: CONTROVERSIES AND CHALLENGES** Aula B1 **Opening Session:** Prof. Kristofor Lapa (UV)	**Use of AI in the Process of Green Transformation and Impact on Public Health** - Esmeralda Hamiti, Federika Alliaj, Kristi Metushi
12:15-12:30	**The Adoption of Electric Vehicles in Albania: A Comparative Study with Other Western Balkan Countries** - Doklejda Hodaj, Andrea Lapa	**Development of an Automatic Traffic Sign Detection System Using YOLOv8** - Valentina Vojinović, Luka Filipović
12:30-12:45	**Application of Quality Tools in the Analysis of Factors Influencing the Development of Electromobility in Montenegro** - Jelena Šaković Jovanović, Draško Jovanović, Mirjana Grdinić Rakonjac, Marko Lučić, Miloš Perović, Aleksandar Vujović, Gordana Radulović	**The Historical Development of Artificial Intelligence and Its Influence on the job market in Automotive Engineering** - David Josef Pilgram
12:45 – 13:45	**Questions and Discussion**	**Questions and Discussion**
13:45	**Lunch**	

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