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UNIVERSITETI POLIS

BOOK OF PROCEEDINGS

INTERNATIONAL CONFERENCE

SUSTAINABLE MOBILITY

5-6 MARCH

2026

The INTEC International Conference brings together academics, researchers, policymakers and industry experts to discuss innovative approaches and collaborative solutions for a sustainable future in engineering and mobility. The conference will be hosted by POLIS University in Tirana, Albania, and co-organized by partners from across the EU as part of the Erasmus+ CBHE Project 101081873-ERASMUS-EDU-2022-CBHE-STRAND-2.

INTEC International Engineering Competence Centres to push sustainable mobility development in Albania and Montenegro
Project Reference: 101081873-ERASMUS-EDU-2022-CBHE-STRAND-2

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Project Partners:

FH JOANNEUM University of Applied Sciences · Frankfurt University of Applied Sciences · UPT · UCG · UDG · AVL · GAMA-AUTO · ALFA Centar

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Project Coordinator: FH JOANNEUM Gesellschaft mbH (FHJ), Austria
Frankfurt University of Applied Sciences (FRA-UAS), Germany
University of Split (US), Croatia
POLIS University (POLIS), Albania
Polytechnic University of Tirana (PUT), Albania
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University of Donja Gorica (UDG), Montenegro
AVL List GmbH (AVL), Austria
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DI Daniela Wenzl
Dr. Elona Karafili
Dr. Flora Krasniqi

Conference Keynote Speaker

DI Horst Pflügl, AVL List GmbH (AVL), Austria
MSc. Mine Bushi, General Directorate of Road Transport Services in Albania

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Dr. Keti Hoxha
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MSc. Sindi Doce
MSc. Glejdi Fejza

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INTEC International Conference
February 2026
POLIS University, Tirana, Albania

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EFFECTS OF TECHNICAL TRAFFIC CALMING MEASURES

DOI: 10.37199/c41001040

Filip PEROVIĆ
University of Montenegro, Montenegro
perovic.fp@gmail.com

Abstract

This study examines the effectiveness of different traffic calming devices in reducing vehicle speeds on a regional road in Montenegro. Traffic data were collected using unmanned aerial vehicles and analysed with DataFromSky software for 12207 vehicles. The results show that vertical measures, such as rubber humps and asphalt platforms, are the most effective in reducing speeds, while lane narrowing and rumble strips have limited impact. These findings highlight the importance of selecting appropriate traffic calming measures to improve road safety, particularly in high-risk areas.

Keywords: traffic calming devices, speed management, DataFromSky

I. INTRODUCTION

Speeding is one of the most influential risk factors in road traffic accidents, as it directly affects both the likelihood of a crash and the severity of its consequences (Aarts & Van Schagen, 2006). Higher vehicle speeds reduce the available reaction time for drivers, increase stopping distances, and intensify the kinetic energy released during a collision, which significantly raises the probability of severe injuries or fatalities. Even relatively small increases in speed can lead to disproportionately higher risks, particularly for vulnerable road users such as pedestrians, cyclists, and motorcyclists. Previous research indicates that a 1% increase in vehicle speed is associated with an approximately 11% increase in pedestrian fatality risk in the event of a collision (Kruszyna & Matczuk-Pisarek, 2021). For this reason, speed limits of 30 km/h are widely considered appropriate in areas with frequent pedestrian activity, such as school zones and residential streets.

In response to these safety concerns, speed management has become a central objective of modern traffic safety policy. One of the most commonly applied approaches involves the implementation of traffic calming devices, which aim to physically or perceptually influence driver behavior and encourage compliance with posted speed limits. These measures are particularly

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important in locations with increased conflict potential between motor vehicles and vulnerable road users. In Montenegro, traffic calming measures defined by national regulations include speed humps, raised platforms, partial platforms, lane narrowings, rumble and vibration strips, as well as optical warning elements and other visual cues. While such devices are widely used, their effectiveness varies depending on their design, placement, and local traffic conditions. Therefore, systematic evaluation under real traffic conditions is essential. This study addresses this need by assessing the effectiveness of selected traffic calming devices using drone-based data collection, which enables objective observation of vehicle behavior without influencing drivers.

Previous studies consistently confirm the effectiveness of vertical traffic calming measures. Johansson et al. (2011) found that speed cushions placed before pedestrian crossings reduced average speeds to approximately 22–23 km/h and improved driver yielding behavior. Antić et al. (2013) reported speed reductions of up to 37% depending on hump height. Raised platforms have also been associated with substantial reductions in injury crashes, particularly when combined with pedestrian crossings (Makwasha & Turner, 2017).

In contrast, horizontal measures such as lane narrowing and rumble strips often produce weaker effects. Andrijašević et al. (2024) showed that rumble strips reduce speed modestly but rarely ensure compliance with posted limits. These findings highlight the need for comparative evaluations under similar traffic conditions.

II. METHODOLOGY

Research was conducted at five 30 km/h zones featuring traffic calming on the R-23 Podgorica-Danilovgrad route. The spatial distribution of the analysed locations along the R-23 corridor is presented in Figure 1. The selected sites were chosen to enable a comparative assessment of traffic calming measures under similar traffic, geometric, and environmental conditions, while differing primarily in the type of installed device.

Traffic flow was recorded using a DJI Mini 3 unmanned aerial vehicle, allowing unobtrusive data collection without direct interaction with drivers and thus ensuring natural driving behaviour, as confirmed in previous studies (Andrijašević et al., 2024). DataFromSky AI software was used to process video footage for precise vehicle tracking and traffic analysis.

Within the software environment, four virtual cross-sections (gates) were defined for each traffic direction: 30 m and 15 m upstream of the traffic calming device, directly at the device, and 15 m downstream. This gate configuration allowed for detailed analysis of vehicle speed and acceleration patterns before, during, and after the interaction with the traffic calming element.

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The final dataset comprised a total of 12207 vehicles, providing a robust empirical basis for statistical analysis. Preliminary examination of the data revealed that vehicle speed distributions deviated from normality; therefore, nonparametric statistical methods were applied. Differences in vehicle speeds between traffic directions and between locations were assessed using the Mann–Whitney U test, while differences across multiple gates were evaluated using Friedman's analysis of variance (Spiegel et al., 2011). This methodological approach ensured reliable identification of statistically significant effects attributable to the presence and type of traffic calming devices.

III. RESULTS

Analysis was based on 12,207 vehicles across five sites on the R-23. Data distribution (Table 1) ranges from a high of 31.07% at Location D to a low of 7.8% at Location E. This uneven distribution reflects differences in traffic volumes and lane configurations at the observed sites, particularly the fact that rumble strips were installed in only one traffic lane. Nevertheless, the sample size at all locations was sufficient to support statistically reliable comparisons.

Vehicle speed analysis across the defined gates revealed clear and statistically significant differences, confirming the influence of traffic calming devices on driving behavior. When comparing speeds at the entry gate (30 m upstream) and at the device itself (gate 0 m), a noticeable reduction in speed was observed, particularly at locations equipped with vertical deflection measures. These differences are more clearly illustrated by the Box & Whisker diagrams shown in Figure 2, which present the median, minimum, and maximum speeds, as well as the interquartile ranges (25–75% of the analysed vehicle sample) for each measurement gate.

As shown in Figure 2, the lowest vehicle speeds were consistently recorded at gate 0 m, corresponding to the position of the traffic calming device. At this gate, the interquartile range of speeds varied between approximately 18 km/h and 42 km/h, with the lowest interquartile value of 18 km/h observed across all gates. In contrast, higher speed values were recorded at the upstream gate located 30 m before the device, where the interquartile range extended from approximately 37 km/h to 46 km/h, representing the highest typical speeds prior to interaction with the calming measures. At the intermediate upstream gate (15 m) and the downstream gate (+15 m), similar interquartile speed ranges were observed, indicating gradual deceleration when approaching the device and a controlled acceleration after passing it. This pattern confirms the presence of a localized traffic calming effect extending beyond the device itself.

Friedman's analysis of variance confirmed that the observed differences in speed distributions between the gates were statistically significant ($p < 0.001$), indicating that traffic calming devices

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have a measurable impact on vehicle speeds not only at the point of installation but also within their immediate influence zone.

A more detailed comparison of speeds at gate 0 m further highlighted substantial differences between individual traffic calming device types. The lowest median speeds were recorded at Location B (rubber humps), with a median value of 16.9 km/h, followed by Location D (asphalt platform), where the median speed was 18.4 km/h. These values are well below the posted speed limit of 30 km/h, demonstrating that vertical traffic calming devices effectively enforce speed reduction and promote compliance in school zone conditions. In contrast, Location C (lane narrowing) exhibited the highest median speed at gate 0 m, reaching 62.9 km/h, along with the widest interquartile range and the highest maximum recorded speed (132 km/h), indicating both poor speed-reduction performance and substantial variability in driver behavior.

The limited effectiveness of lane narrowing can be partly attributed to site-specific conditions, as data were collected during both vehicle encounters and free-flow situations. When opposing traffic was absent, drivers often had access to the full available roadway width, reducing the perceived constraint and allowing higher speeds. Location E (rumble strips) showed a moderate reduction in speed compared to lane narrowing; however, median speeds remained above the legal limit, indicating that this measure alone is insufficient to ensure adequate speed control in high-risk zones.

Statistical testing further confirmed these observations. The nonparametric median test revealed statistically significant differences in speed distributions at gate 0 m across the analysed locations ($p < 0.001$), demonstrating that the type of traffic calming device has a decisive impact on vehicle speed. Additionally, Mann-Whitney U tests indicated statistically significant differences in speed between traffic directions, suggesting that roadway geometry and driving dynamics also influence speed behavior.

Overall, the results clearly show that vertical traffic calming measures, such as rubber humps and asphalt platforms, are substantially more effective than horizontal or perceptual measures, such as lane narrowing and rumble strips. Furthermore, the analysis confirms that the influence of traffic calming devices extends beyond the device itself, affecting driver behavior in the immediate upstream and downstream areas. These findings provide strong empirical support for prioritizing vertical traffic calming devices in school zones and similar environments with a high presence of vulnerable road users.

IV. DISCUSSION/CONCLUSION

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The results clearly confirm that vertical deflection measures are substantially more effective in reducing vehicle speeds than horizontal or perceptual traffic calming devices. Rubber speed humps and raised asphalt platforms enforce speed reduction through direct physical interaction between the vehicle and the roadway, which has been consistently identified in previous research as the most reliable mechanism for achieving compliance with low speed limits (Antić et al., 2013; Makwasha & Turner, 2017). In contrast, measures such as lane narrowing and rumble strips rely primarily on driver perception, anticipation, and situational awareness, resulting in less consistent speed-reducing effects and greater variability in driver behavior (Andrijašević et al., 2024).

The limited effectiveness of lane narrowing observed in this study can be partly explained by site-specific traffic conditions. When vehicles do not encounter opposing traffic, drivers often have access to the full available roadway width, which reduces the perceived constraint and allows higher speeds to be maintained. Similar findings have been reported in studies showing that perceptual measures alone are insufficient to ensure sustained speed reduction, particularly on roads with higher design speeds (Makwasha & Turner, 2013). Rumble strips demonstrated only modest speed reductions and failed to ensure compliance with the posted 30 km/h limit, which is consistent with previous research indicating that such measures primarily act as warning devices rather than strict speed-control elements (Andrijašević et al., 2024).

Analysis across multiple measurement points revealed that speed reductions were most pronounced directly at the traffic calming device; however, the effect remained evident in the immediate upstream and downstream areas. This confirms the presence of a localized traffic calming effect, whereby drivers begin to decelerate before reaching the device and gradually accelerate after passing it. Statistically significant differences between measurement gates further confirm that traffic calming elements influence vehicle speeds not only at the point of installation but also within their immediate surroundings (Spiegel et al., 2011).

Overall, this study demonstrates that rubber humps and asphalt platforms are the most effective traffic calming devices for reducing vehicle speeds on regional roads within school zones. Horizontal and perceptual measures, such as lane narrowing and rumble strips, showed limited effectiveness and would require additional design elements-such as physical barriers, vertical deflection, or combined treatments-to achieve meaningful and consistent speed reductions. The use of drone-based data collection proved to be a reliable and objective method for traffic analysis, enabling unobtrusive observation of natural driver behavior, as also confirmed in recent traffic safety studies (Andrijašević et al., 2024). These findings strongly support prioritizing vertical traffic calming measures in locations with a high presence of vulnerable road users and provide a solid empirical basis for future improvements in traffic safety planning and road design.

Table 1: Frequency for the categorical variable Location

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Location	Number	Cumulative number	Percentage	Cumulative percentage
A	2682	2682	21.97	21.97
B	2254	4936	18.47	40.44
C	2526	7462	20.69	61.13
D	3793	11255	31.07	92.2
E	952	12207	7.8	100

Fig. 1: Locations of observed traffic calming devices on the R-23 road

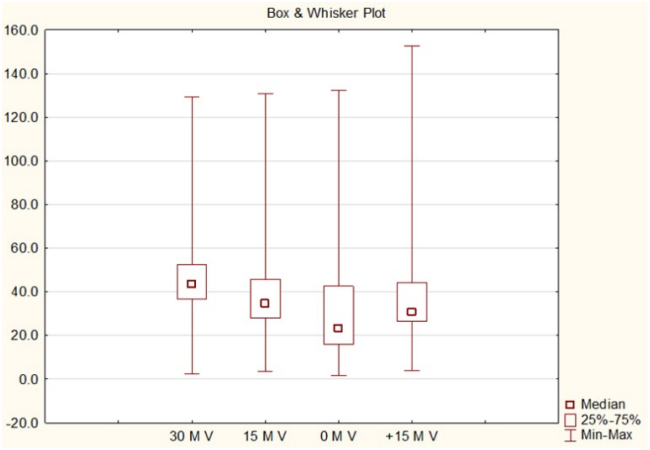

Fig. 2: Vehicle speeds at different gates

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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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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

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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