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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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05

INTEGRATING EVENT DATA RECORDER (EDR) TECHNOLOGY INTO SUSTAINABLE ROAD SAFETY FRAMEWORKS WITHIN THE EUROPEAN GREEN DEAL

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Abstract

This study examines the role of Event Data Recorders (EDRs) in modern road accident investigation and connects their function to emerging frameworks of sustainable and safe mobility within the European Green Deal. EDRs are electronic systems installed in vehicles capable of recording critical pre-crash and crash-related data, enabling accurate forensic reconstruction and evidence-based evaluation of traffic incidents. While EDR technology has traditionally been associated with vehicle safety and legal investigation, recent European transport policies – including the European Green Deal and the Sustainable and Smart Mobility Strategy – recognize safety as a core dimension of sustainability. Reducing fatal and severe road accidents preserves human life (social sustainability), reduces socio-economic losses (economic sustainability), and supports resilient mobility systems (institutional sustainability). The study integrates technical, regulatory, and sustainability perspectives by analysing EDR development, data retrieval methods, legal frameworks, and a real crash case involving emergency braking. Findings show that EDR-generated evidence increases

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reconstruction accuracy, enhances transparency in insurance and judicial processes, and contributes to safety objectives embedded within EU sustainability targets such as Vision Zero 2050. Ultimately, EDR adoption strengthens the connection between sustainable transport, traffic safety, and responsible mobility. In conclusion, the use of black boxes increases road safety, as they can identify dangerous driver behaviours and provide accurate evidence during accident investigations. This study emphasizes the importance of implementing black box technology in all vehicles to improve accident monitoring and protect human lives.

Keywords*:* sustainability, accident reconstruction, EDR

I. INTRODUCTION

Modern vehicles are increasingly equipped with advanced electronic systems that enable continuous data monitoring, logging, and communication between vehicle subsystems. Among these, the Event Data Recorder (EDR) plays a critical role in reconstructing road accidents by capturing second-level pre-crash and crash data relevant to technical, forensic, and legal investigations (National Highway Traffic Safety Administration [NHTSA], 2014; Bosch, 2023). Typical parameters recorded include vehicle speed, brake status, accelerator position, engine RPM, seatbelt usage, and steering wheel angle (Gabauer & Gabler, 2008).

Historically, EDR systems emerged in the 1970s as part of airbag diagnostic modules designed primarily to ensure correct deployment during collisions (Hughes et al., 1999). Over time, they evolved into forensic tools capable of storing high-integrity crash data. Today, standardized retrieval tools such as the Bosch Crash Data Retrieval (CDR) platform provide structured access to vehicle data for expert accident reconstruction.

Simultaneously, the legal landscape around EDRs has evolved. Regulatory authorities, particularly in the United States and Europe, have established standards and requirements for crash data retention and accessibility (ISO, 2021; European Commission, 2021). From 2024 onward, EDR installation becomes mandatory for new vehicles in the European Union (European Commission, 2021). In parallel with technological development, the legal framework governing EDR usage evolved, particularly in the United States and Europe. Since the first court case involving EDR data in 1994, regulatory bodies such as the National Highway Traffic Safety Administration (NHTSA) have progressively introduced standards (NHTSA, 2014; ISO, 2021). This process culminated in mandatory EDR implementation for all new vehicles sold from 2024 onward (European Commission, 2021).

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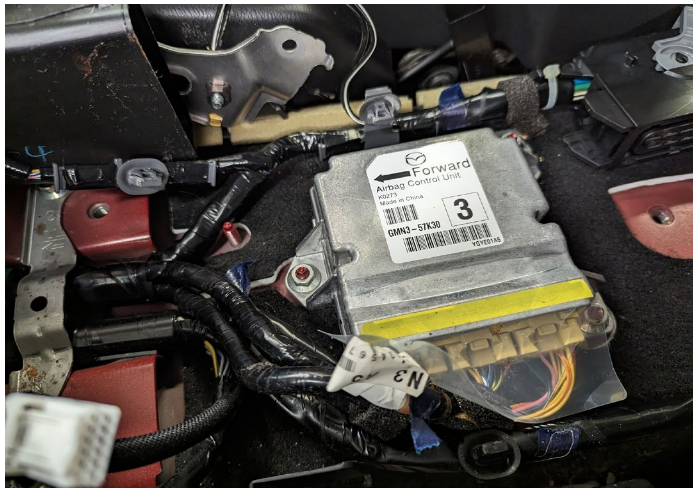

Figure 1. Sample of EDR.

I.1 Safety as a dimension of sustainability

Traditional views treated road safety as a technical safety matter. However, European mobility policy increasingly frames safety within sustainability, because:

- fatalities and severe injuries impose high social costs,
- road accidents cost the EU an estimated €280 billion annually in socio-economic losses,
- safe mobility supports economic resilience and public health,
- reducing crashes contributes to institutional sustainability.

The European Green Deal (European Commission, 2019) and the Sustainable and Smart Mobility Strategy (European Commission, 2020) explicitly identify safe mobility as a pillar of sustainable mobility alongside environmental decarbonization and digital transformation. Within this context:

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Figure 2. Safety = Sustainable, created by ChatGPT.

EDR technology supports these principles by enabling evidence-based accident prevention, judicial transparency, insurance evaluation, and traffic behaviour analysis.

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II. BACKGROUND AND REGULATORY

II.1 EDR Technology

EDR technology began with General Motors' Sensing Diagnostic Module (SDM) in the 1970s. Initially, data storage occurred only when airbags deployed. Later generations expanded storage windows to include pre-crash intervals (Hughes et al., 1999). Current EDR systems record:

- pre-crash vehicle dynamics (speed, brake, throttle),
- crash pulse data,
- restraint system engagement,
- seatbelt usage,
- occupant information.

When a predefined triggering event occurs, the EDR stores a snapshot of these parameters for later analysis.

II.2 Technical standards & regulation

Key regulatory frameworks include:

- NHTSA Final Rule (2014) defining minimum data elements for EDRs in the US,
- ISO 19237:2021 defining international EDR standards,
- EU Regulation 2019/2144 making EDR installation mandatory in new vehicles from 2024,
- GDPR implications for data privacy and ownership.

These frameworks standardize data collection, storage, and admissibility in legal or insurance contexts.

II.3 Safety within the European Green Deal

The European Green Deal (2019) aims to make the EU climate-neutral by 2050. Although primarily environmental, it includes transport-related sustainability pillars:

- decarbonization,
- modal shift,
- digital mobility,
- infrastructure,
- safety.

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In parallel, the Sustainable and Smart Mobility Strategy (2020) targets:

- 50% reduction in road fatalities by 2030,
- Vision Zero by 2050.

EDR integration supports these objectives through:

- crash analysis (policy feedback),
- behaviour profiling (driver safety),
- reduction in fatalities (social sustainability),
- reduction in insurance/legal costs (economic sustainability).

Thus, EDR technology reinforces EU mobility sustainability.

III. METHODOLOGY

III.1 EDR hardware integration

EDRs are usually integrated in the Airbag Control Module (ACM) but may also reside in:

- Powertrain Control Module (PCM),
- Roll Over Sensor (ROS),
- Active Safety Control Module (ASCM).

III.2 Vehicle data communication

EDR systems do not generate data but record data from other Electronic Control Units (ECUs) via the vehicle's CAN Bus. Continuous data streams include:

- wheel speed sensors,
- brake pedal sensors,
- throttle position,
- steering wheel angle,
- seatbelt status.

III.3 Data retrieval methods

According to NHTSA (2014), EDR data can be retrieved via:

1. OBD-II diagnostic port (most common),
2. Direct-to-module cable connection,

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3. Advanced protocols (FlexRay, serial).

The Bosch CDR software requires VIN entry to:

- identify the correct module,
- auto-select protocols,
- display connector locations,
- ensure compatibility.

III.4 Data storage and integrity assurance

After data reading, verification, and decoding, the Bosch CDR system enters a critical phase: data storage and integrity assurance. The retrieved data are saved in a dedicated file with the extension, CDRx, which represents the official Bosch CDR format. The .CDRx file contains:

- Original raw data (HEX data): stored exactly as read from the EDR
- Decoded data: automatically generated using the appropriate Software ID
- Technical meta-information: including date and time of reading, tools used, reading method, and operator identification

Once a .CDRx file is saved, it is protected against any modification. The file is locked within the Bosch CDR system, ensuring that the original data remains unchanged and fully traceable, which is essential for legal and forensic applications.

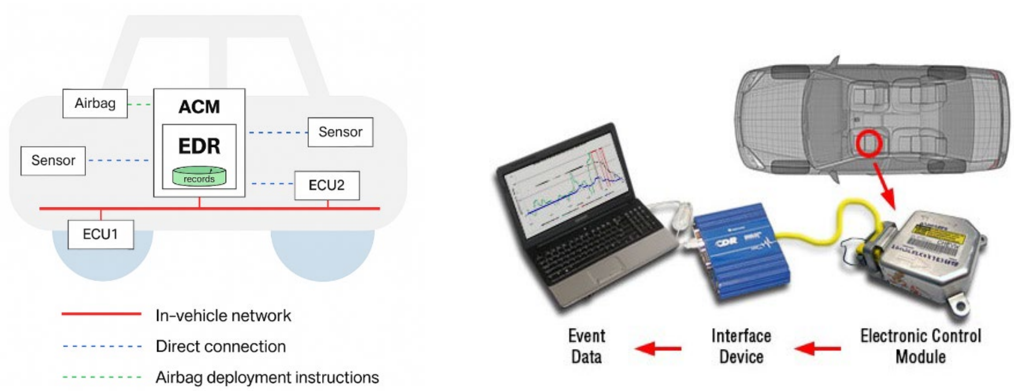

Figure 3. Flow chart for EDR data storage.

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Figure 4. Flow chart for EDR data storage.

IV. RESULTS & TECHNICAL CASE STUDY

IV.1 Crash scenario overview

In a real emergency braking case, EDR output captured:

- vehicle speed profile,
- accelerator pedal = 0%,
- brake pedal = activated.

Two braking phases were identified:

Table 1. Phases for analysis speed and deacceleration from EDR.

Phase 1: –1.0 s to –0.5 s	**Phase 2: –0.5 s to 0.0 s**
• Speed: **173 km/h → 164 km/h** • Δv = 9 km/h over 0.5 s • Deacceleration ≈ **5.0 m/s²**	• Speed: **164 km/h → 148 km/h** • Δv = 16 km/h over 0.5 s • Deacceleration ≈ **8.88 m/s²**

These values are characteristic of high-load emergency braking on the vehicle's front axle, indicating escalating brake intensity.

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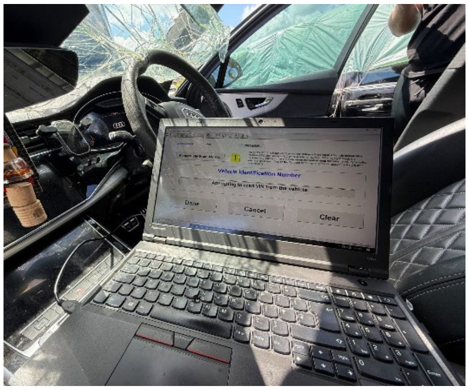

BOSCH | CDR CRASH DATA RETRIEVAL

IMPORTANT NOTICE: Robert Bosch LLC and the manufacturers whose vehicles are accessible using the CDR System urge end users to use the latest production release of the Crash Data Retrieval system software when viewing, printing or exporting any retrieved data from within the CDR program. Using the latest version of the CDR software is the best way to ensure that retrieved data has been translated using the most current information provided by the manufacturers of the vehicles supported by this product.

CDR File Information

User Entered VIN	[illegible]
User	
Case Number	
EDR Data Imaging Date	05/07/2025
Crash Date	
Filename	[illegible]
Saved on	Wednesday, May 7 2025 at 14:27:25
Imaged with CDR version	Crash Data Retrieval Tool 24.2.357
Imaged with Software Licensed to (Company Name)	[illegible]
Reported with CDR version	Crash Data Retrieval Tool 24.2.357
Reported with Software Licensed to (Company Name)	[illegible]
EDR Device Type	Airbag Control Module
Event(s) recovered	Record 1, Record 2, Record 3, Record 4, Record 5, Record 6

BOSCH | CDR CRASH DA RETRIEVA

System Status at Event (Record 1, Most Recent)

Event Counter at Event	11
Multi-Event, Number of Events	1st event
Time from Initial Event to Current Event (msec)	0.0
Vehicle Clock, Date and Time at Event (YYYY-MM-DD, HH:MM:SS)	2024-08-11, 10:49:47
Vehicle Mileage (km)	55,870
Operating Time (min)	78,639
Ignition Cycle at Event (Cycle)	4,698
Ignition Cycle at Download (Cycle)	4,757
Maximum Delta-V, Longitudinal (MPH [km/h])	-8.7 [-14]
Time, Maximum Delta-V, Longitudinal (msec)	300
Maximum Delta-V, Lateral (MPH [km/h])	1.2 [2]
Time, Maximum Delta-V, Lateral (msec)	58
Time, Maximum Delta-V, Resultant (msec)	300
Time from Last Speed Data Sample (Precrash) to Time Zero (msec)	10
Vehicle Identification Number (VIN)	WAUZZZ4M4MD000447
FAZIT Identification String	YNF-GDL02.06.2015630611
Part Number, ACM	4KE959655H
Hardware Version, ACM	H42
Software Version, ACM	3303
Serial Number ECU	0032BM001YD0
Supplier ID, ACM	YNF
Production Date, ACM	200602
Application Version, ACM	2625
Part Number, ACM Software	4M0909602CA
Complete File Recorded	Yes

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BOSCH

CRASH DATA RETRIEVAL

Pre-Crash Data -5 to 0 sec (Record 1, Most Recent)

Time (sec)	Anti-lock braking system activity	Stability Control	Speed, Vehicle Indicated (MPH [km/h])	Accelerator pedal, % full (%)	Service brake, on/off
-5.0	Non-Engaged	On	101 [162]	69	Off
-4.5	Non-Engaged	On	102 [164]	71	Off
-4.0	Non-Engaged	On	104 [167]	72	Off
-3.5	Non-Engaged	On	105 [169]	71	Off
-3.0	Non-Engaged	On	107 [172]	70	Off
-2.5	Non-Engaged	On	108 [174]	67	Off
-2.0	Non-Engaged	On	109 [176]	33	Off
-1.5	Non-Engaged	On	109 [175]	0	Off
-1.0	Non-Engaged	On	107 [173]	0	On
-0.5	Non-Engaged	On	103 [165]	0	On
0.0	Non-Engaged	On	92 [148]	0	On

Figure 5. Analysing Crash Data retrieved from a crashed car EDR.

IV.2 Forensic implications

EDR data enabled reconstruction of:

- reaction time,
- brake timing,
- vehicle dynamics,
- severity estimation.

IV.3 Integrity and legal value

Because .CDRx files are immutable, they possess:

- evidential value in court,
- transparency in insurance disputes,
- repeatability for research.

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IV.4 Sustainability implications

EDR contributes to sustainability by:

- reducing fatalities → social sustainability,
- reducing crash-related public cost → economic sustainability,
- supporting policy evaluation → institutional sustainability.

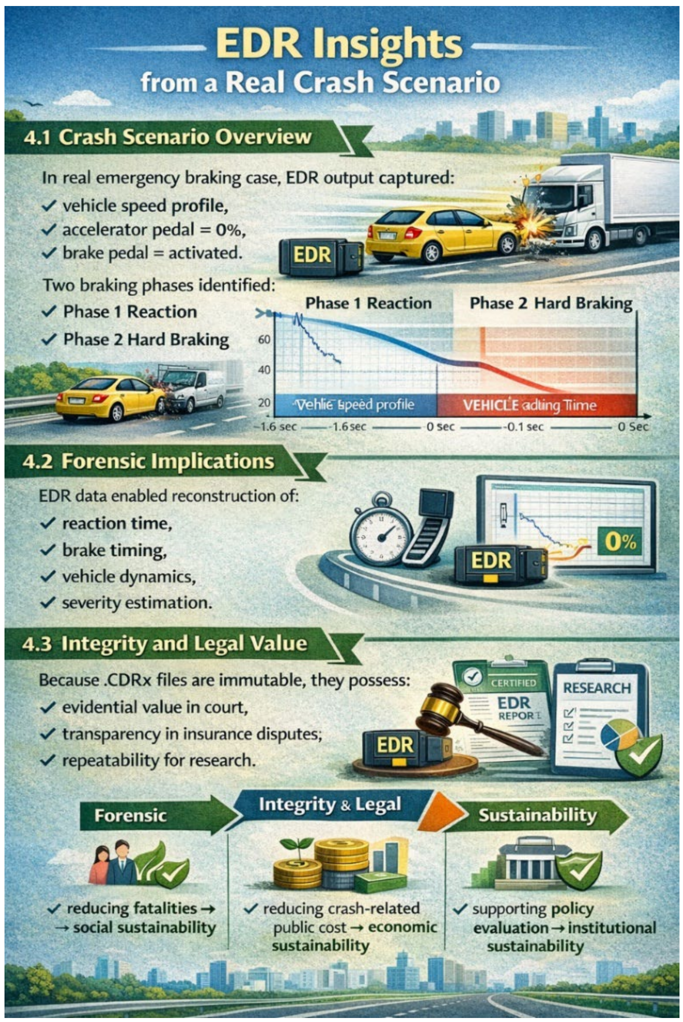

Figure 6. EDR insight, created by ChatGPT.

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V. DISCUSSION AND CONCLUSION

This study demonstrates that EDR systems are not merely engineering tools but sustainability enablers. The European Green Deal and Vision Zero integrate safety into sustainability due to the socio-economic burden of road crashes.

EDR enables, improved forensic reconstruction, accurate judicial evaluation, faster insurance settlement, identification of high-risk patterns, data for automated/connected vehicle policies.

Barriers include data privacy and GDPR constraints, standardization gaps across manufacturers, insurance access debates, limited public awareness.

Future integration with V2X, ADAS, and autonomous driving systems will enhance sustainable mobility outcomes.

Event Data Recorders constitute a vital component of sustainable and safe mobility. Their technical capability to capture objective vehicle data strengthens accident analysis, legal transparency, insurance fairness, and policymaking.

As the EU transitions toward Vision Zero 2050, mandatory EDR adoption will play a pivotal role in decreasing road-related fatalities and injuries. By aligning with the European Green Deal, EDR technology contributes to sustainability across social, economic, and institutional dimensions.

Future research should focus on:

- standardizing EDR data models globally,
- integrating EDR into autonomous vehicle data frameworks,
- balancing data privacy with public safety,
- leveraging EDR datasets for AI-based safety analytics.

AKNOWLEDGEMENTS

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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	
	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.	**Questions and Discussion**
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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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

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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