



Sustainable Transportation within the framework of Green Deal

Laboratory Manual



Academy of Applied Studies of Kosovo and Metohija



Laboratory Manual

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Contents

Introduction.....	1
1. Laboratory for Sustainable Transport	4
2. Equipment in the Laboratory for Sustainable Transport.....	8
2.1. The Role of Equipment in Teaching, Research, and Professional Practice	9
2.2. Connection with Equipment from Other Erasmus+ Projects	10
3. The VIVE Pro Eye VR Headset	12
3.1. Importance for Teaching.....	13
3.2. Examples of Student Activities.....	14
3.3. Importance for Scientific Research.....	15
3.4. Importance for Sustainable Transportation and Intelligent Transport Systems	15
4. SOFTWARE FOR TRAFFIC SIMULATION AND ANALYSIS	17
4.1. Importance for Teaching.....	18
4.2. Examples of Student Activities.....	18
4.3. Importance for Scientific Research.....	19
4.4. Importance for Sustainable Transportation and Intelligent Transport Systems	20
5. DRIVING SIMULATOR.....	22
5.1. Importance for Teaching.....	23
5.2. Examples of Student Activities.....	24
5.3. Importance for Scientific Research.....	24
5.4. Importance for Sustainable Transportation and Intelligent Transport Systems	25
6. TRAFFIC RECORDING DEVICES	26
6.1. Importance for Teaching.....	26
7.2. Examples of Student Activities.....	27
6.3. Importance for Scientific Research.....	28
6.4. Importance for Sustainable Transportation and Intelligent Transport Systems	29
CONCLUSION.....	31

Introduction

The contemporary development of transport and traffic systems is increasingly guided by the principles of sustainable mobility, which aim to balance the growing demand for the movement of people and goods with the requirements of environmental protection, traffic safety, energy efficiency, digital transformation, and social accessibility. In this context, higher education institutions play an important role in preparing professionals capable of analyzing, planning, and improving transport systems in accordance with modern European policies and the principles of the Green Deal.

This laboratory manual was developed within the framework of the Erasmus+ project SPHERE – Sustainable Transportation within the Framework of Green Deal (Project No. 101128065), whose primary objective is to improve the quality of higher education in the field of sustainable transportation, modernize study programs, and strengthen their relevance to the labor market and society. The project is also focused on the application of modern scientific approaches, the exchange of European good practices, and the enhancement of professional competencies in the field of transport and traffic engineering.

The particular value of this manual lies in connecting theoretical knowledge in sustainable transportation with practical laboratory work. The equipment acquired through the SPHERE project enables students, teachers, researchers, and professionals to gain practical experience through measurements, simulations, analyses, and experimental activities, while developing a deeper understanding of current challenges in modern transport systems. In this way, the laboratory becomes a space for applying knowledge, developing research skills, and testing solutions aimed at creating safer, more efficient, and more sustainable transportation systems.

The manual is primarily intended for undergraduate and master's students, academic staff, researchers, and professionals in the field of transport and traffic engineering who participate in professional training and lifelong learning activities. Its main purpose is to provide clear guidelines for the use of laboratory equipment, define potential areas of application, and ensure a standardized approach to practical activities. At the same time, the manual encourages an interdisciplinary approach, considering that sustainable transportation integrates traffic engineering, urban planning, environmental protection, traffic safety, information technologies, and public policy.

Through descriptions of the laboratory equipment, examples of practical exercises, and various application scenarios, this manual contributes to the

modernization of the teaching process and the strengthening of users' practical competencies. At the same time, it represents one of the outcomes of institutional capacity building and development within the SPHERE project. The acquired equipment serves not only as technical support for teaching activities, but also as a foundation for future research, professional analyses, training activities, and cooperation with industry, public institutions, and other relevant stakeholders.

Based on the above, this laboratory manual has a dual role. On the one hand, it serves as a practical guide for the use of equipment acquired within the SPHERE project. On the other hand, it highlights the importance of laboratory-based learning in educating professionals capable of responding to the contemporary challenges of sustainable transportation, green mobility, and traffic safety. In this way, the manual contributes to the long-term sustainability and practical implementation of the project results in education, research, and professional practice.

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1. Laboratory for Sustainable Transport

Within the framework of the Erasmus+ project SPHERE – *Sustainable Transportation within the Framework of Green Deal*, the Laboratory for Sustainable Transport was established at the Academy of Applied Studies Kosova and Metohija as a modern teaching and research unit dedicated to the advancement of education, research, and practical application of knowledge in the field of sustainable transportation and mobility.

The establishment of the laboratory represents an important step in strengthening the institutional capacities of the Academy for the modern study of transportation and traffic systems. The laboratory was created with the aim of connecting theoretical knowledge with practical work, field research, measurements, data analysis, simulations, and the application of contemporary technical and software equipment. In this way, the laboratory becomes a space where teaching activities, professional practice, and research mutually complement each other and contribute to solving real-world problems related to mobility, traffic safety, efficiency, and sustainability of transport systems.

The primary goal of the laboratory is to provide students, teachers, researchers, and professionals with a working environment that reflects the contemporary needs of the transport profession. Within such an environment, it is possible to analyze transport system performance, examine road user behavior, assess the impact of infrastructure on mobility and safety, evaluate environmental aspects of transportation, and apply digital tools in traffic planning, modeling, and management processes.

A particularly important role of the laboratory lies in the implementation of an evidence-based approach. Modern transportation planning requires the systematic collection, processing, and interpretation of relevant data as a basis for informed decision-making. In this regard, the equipment acquired through the SPHERE project enables the analysis of various transportation-related aspects — from traffic flow characteristics and user behavior to infrastructure conditions, environmental impacts, and quality of life in urban areas.

The acquired equipment plays a significant role in developing practical competencies. It enables the implementation of laboratory exercises, field measurements, demonstration activities, student projects, professional analyses, and scientific research. Special emphasis is placed on the application of equipment

in the areas of sustainable transportation, urban mobility, active transportation modes, public transport, traffic safety, transportation analytics, digitalization of transport infrastructure, and environmental impact assessment.

Within the laboratory, various practical and research activities can be carried out. Students can learn how to collect and analyze traffic flow data, evaluate conditions for walking and cycling, assess the functioning of public transport systems, identify traffic conflicts and safety risks, and simulate different traffic organization scenarios using modern software tools. In this way, the laboratory enables theoretical concepts to be transformed into practical experience, measurable results, and applied knowledge.

An additional value of the laboratory lies in its interdisciplinary role. Sustainable transportation integrates multiple interconnected fields, including traffic engineering, urban planning, traffic safety, environmental protection, energy efficiency, digitalization, and public policy. Therefore, the laboratory serves as a common platform for the implementation of various educational and research activities and enables students to understand transportation as a complex system in which technical solutions must be aligned with user needs, safety requirements, and sustainable development principles.

The Laboratory for Sustainable Transport contributes to the modernization of the educational process through the implementation of contemporary teaching methods and practical learning approaches. Instead of relying solely on theoretical instruction, students are encouraged to actively participate in the research process by identifying problems, collecting and analyzing data, interpreting results, and proposing improvement measures. Such an approach is fully aligned with the need to educate professionals capable of addressing modern mobility challenges, including congestion, pollution, traffic safety issues, and the growing need for sustainable modes of transportation.

The significance of the laboratory is especially evident in the field of sustainable urban mobility. Modern cities face numerous challenges, such as excessive dependence on private cars, air pollution, noise, traffic congestion, and inadequate safety conditions for pedestrians and cyclists. Through laboratory work, these problems can be analyzed, different solutions can be tested, and recommendations can be developed to contribute to a safer, more efficient, and environmentally friendly transportation system.

The laboratory also plays an important role in supporting active mobility. Walking and cycling are among the most sustainable forms of movement, but their

development requires safe, accessible, and high-quality infrastructure. In this context, the laboratory enables the analysis of pedestrian and bicycle flows, assessment of mobility conditions, identification of spatial barriers and safety risks, and formulation of measures aimed at improving mobility conditions.

In addition to active mobility, the laboratory also supports the analysis of public transport as one of the key components of a sustainable transportation system. Through laboratory and field activities, it is possible to assess stop accessibility, service quality, reliability, line capacity, and opportunities for integrating public transport with walking, cycling, and other mobility modes.

The laboratory also enables the development of knowledge in the field of traffic modeling and simulation. By applying modern software tools, it is possible to create digital models of intersections, street networks, corridors, and urban zones, as well as to analyze the effects of different organizational and infrastructural measures. Simulations make it possible to evaluate the consequences of traffic regime changes, priority measures for public transport, signal timing modifications, or traffic calming measures before their implementation in real conditions.

An important segment of the laboratory's work is related to traffic safety. Sustainable transportation cannot be considered separately from safety, since a transport system associated with a high level of risk and casualties cannot be considered sustainable. Laboratory equipment and methodologies enable the analysis of road user behavior, identification of hazardous locations, speed analysis, conflict analysis, and other safety indicators, which may be valuable for education, research, and cooperation with institutions responsible for traffic safety improvement.

The laboratory also has an important role in the field of environmental protection. Since transportation represents a major source of greenhouse gas emissions, noise, energy consumption, and land use, it is essential that future professionals understand how different mobility patterns and transportation systems affect the environment. Through practical activities, environmental aspects of transportation can be analyzed, mobility scenarios compared, and measures for reducing negative transport impacts evaluated.

In addition to its educational and research functions, the laboratory has the potential to become a place of cooperation between the Academy, the public sector, industry, professional organizations, and the local community. The laboratory can serve as a platform for joint projects, professional training, workshops, analyses, and consulting activities, allowing knowledge developed in the academic

environment to be transferred into practice and used to solve real transportation problems.

The equipment catalog presented in the following sections of this manual includes various technological resources selected in accordance with the objectives of the SPHERE project and the needs of modern education and research in sustainable transportation. The greatest value of the equipment is achieved through its integrated application, which enables a more comprehensive understanding of transport system functioning and the relationships between infrastructure, users, vehicles, environment, and management measures.

In this regard, the Laboratory for Sustainable Transport represents much more than a technically equipped facility. It serves as a foundation for the development of a modern educational and research environment in which knowledge is acquired through practical work, experimentation, analysis, and the application of contemporary methods and technologies. Its development contributes to strengthening the role of the Academy of Applied Studies Kosova and Metohija in the modernization of education, the advancement of research, and the promotion of sustainable, safe, and efficient transportation.

Ultimately, the establishment of the Laboratory for Sustainable Transport within the SPHERE project represents a significant investment in the future of education and research in the field of transportation and traffic engineering. It enables the principles of sustainable mobility to be viewed not only as theoretical concepts, but also as practical frameworks for analyzing, planning, and improving real transportation systems. Through the activities of the laboratory, conditions are created for the development of new educational content, improvement of existing study programs, implementation of high-quality research, and support for the transition toward more sustainable mobility in both local and broader communities.

2. Equipment in the Laboratory for Sustainable Transport

The equipment in the Laboratory for Sustainable Transport was acquired with the aim of supporting modern teaching processes, scientific research, and professional practice in the field of sustainable transportation and mobility. In accordance with the objectives of the Erasmus+ project SPHERE – *Sustainable Transportation within the Framework of Green Deal*, the equipment is intended to support the development of practical knowledge and skills of students, teachers, researchers, and professionals in the areas of transport infrastructure digitalization, traffic flow analysis, traffic safety, mobility management, environmental protection, and the application of modern technologies in the planning and improvement of transportation systems.

The development of modern transportation systems requires the use of precise measuring instruments, digital tools, analysis and simulation software, as well as devices that enable field data collection, processing, and visualization. For this reason, the equipment acquired within the SPHERE project was selected to facilitate the connection between theoretical knowledge and practical application. Its use enables the analysis of real transport and traffic-related problems based on relevant data, the development of sustainable mobility scenarios, and the acquisition of competencies necessary for applying modern methods in the planning, management, and improvement of transportation systems.

The particular importance of this equipment lies in its ability to support an integrated approach to transportation analysis. The concept of sustainable transportation is not limited solely to reducing negative environmental impacts, but also includes the development of a safer, more accessible, more efficient, and technologically advanced system for the movement of people and goods.

In this context, the laboratory equipment can be used for various types of activities, including:

- field measurements and data collection,
- digital recording and spatial analysis,
- transportation infrastructure analysis,
- reconstruction of traffic events,
- assessment of mobility and accessibility conditions,

- transport route planning and analysis,
- support for teaching activities and practical exercises,
- preparation of student and scientific research projects,
- implementation of professional analyses and projects.

Within the SPHERE Erasmus+ project, the following equipment and software were acquired:

- Wheel Sensor - Mobile Wheel Sensor Solution,
- PCA Software - Point Cloud Post-processing software (Permanent license),
- ASUS ROG Zephyrus G16 GU605MV-QR148 (2.5K, Core Ultra 7 Processor 155H, 16GB, SSD 1TB, RTX 4060),
- ASUS Zenbook 14 OLED UX3405MA-QD131W (OLED Full HD, Intel Core Ultra 7 155H, 16GB, SSD 1TB, Win 11,
- SANDISK Eksterni SSD Extreme PRO 2TB SDSSDE81-2T00-G25,
- SANDISK Extreme PRO Portable V2 4TB SDSSDE81-4T00-G25 Eksterni SSD,
- ArcGIS Pro Basic,
- VIVE Pro Eye VR headset - HTC VIVE PRO EYE OFFICE VR HEADSET WITH EYE TRACKING,
- PowerBank - HAMA Supreme 24HD 24000mAh Power Bank,
- Multiport hub - SATECHI USB-C Slim 24" iMac Blue Multiport Hub.

2.1. The Role of Equipment in Teaching, Research, and Professional Practice

The equipment available in the laboratory enables the development of practice-oriented teaching and the acquisition of modern professional competencies in the field of sustainable transportation. Students have the opportunity to become familiar with contemporary devices, digital tools, and software used in professional and research practice, while also understanding their application in the analysis and improvement of transportation systems through practical tasks. This is particularly important because modern education in the field of transportation requires students not only to acquire theoretical knowledge, but also to actively participate in processes such as measurement, analysis, simulation, interpretation of results, and decision-making.

From a research perspective, the laboratory equipment enables the implementation of various analyses, studies, and scientific research activities. It is possible to investigate the quality of pedestrian and cycling infrastructure, analyze

traffic conflicts and risks, assess visibility and safety conditions, perform the digitalization of transport corridors, and develop different scenarios for improving transportation systems. Such activities may serve as the basis for scientific papers, master's theses, student projects, professional studies, and other forms of research work.

In practical application, the laboratory can provide support to local governments, public institutions, and other stakeholders in solving transportation and mobility-related problems. Based on the data collected and analyzed in the laboratory, it is possible to prepare recommendations for improving transport infrastructure, enhancing traffic safety, developing active mobility, optimizing transport routes, improving pedestrian and cycling areas, and planning measures aimed at reducing the negative environmental impacts of transportation.

2.2. Connection with Equipment from Other Erasmus+ Projects

Although the primary focus of this manual is on the equipment acquired within the SPHERE Erasmus+ project, it is important to emphasize that the Laboratory for Sustainable Transport also includes additional equipment obtained through other Erasmus+ projects, primarily PELMOB and TRAFSAF, which can also be valuable for teaching, research, and practical activities in the field of sustainable transportation and mobility.

Through the Erasmus+ project TRAFSAF, equipment particularly important for the study of driver behavior and traffic safety was acquired, including a driving simulator and educational demonstration equipment such as alcohol impairment simulation goggles. This equipment can complement the activities of the laboratory, especially in research related to the human factor, risk perception, reaction time, driver behavior, and education on safe participation in traffic. In the context of sustainable transportation, such equipment is important because it contributes to the development of a safer transport system and the improvement of traffic culture.

Equipment acquired through the Erasmus+ project PELMOB may also serve as valuable support for laboratory activities in the field of sustainable mobility, particularly in activities related to mobility analysis, digitalization, data collection and processing, and the application of modern technologies in education and research.

In this way, equipment acquired through different Erasmus+ projects can be integrated and jointly used for the development of modern teaching, scientific research, and practical activities in the field of sustainable transportation.

The equipment acquired within the SPHERE Erasmus+ project represents the main technical and research foundation of the Laboratory for Sustainable Transport. Its application enables infrastructure digitalization, traffic safety analysis, route planning and analysis, data processing and visualization, as well as the development of practical competencies of students, teachers, and professionals. At the same time, the possibility of integrating equipment acquired through other Erasmus+ projects further expands the laboratory's capacities and enables a more comprehensive understanding of transportation systems and sustainable mobility challenges.

In the following chapters, the equipment and software acquired through the SPHERE, PELMOB, and TRAFSAF Erasmus+ projects will be presented in detail, including descriptions of their purpose, application methods, and possibilities for use in teaching, research, and professional work in the field of sustainable transportation.

3. The VIVE Pro Eye VR Headset

The VIVE Pro Eye VR Headset (Figure 1) developed by HTC represents an advanced virtual reality system intended for professional, educational, and research applications. This device integrates eye-tracking technology, enabling precise monitoring of users' visual attention and interaction within virtual environments. Thanks to its high-resolution displays, ergonomic design, and compatibility with various VR platforms and software solutions, the VIVE Pro Eye provides a realistic and interactive virtual simulation experience.



Figure 1. VR device with eye-tracking technology

Within the context of the Laboratory for Sustainable Transport, this VR system has significant value because it enables the simulation and analysis of various traffic and transportation scenarios in a virtual environment. In this way, students, teachers, and researchers can analyze the behavior of traffic participants, evaluate mobility conditions, test infrastructure solutions, and examine the effects of different transport system elements without the need for interventions in real-world conditions.

Virtual reality technology has particular importance in the field of sustainable transportation because it enables safe, controlled, and interactive testing of different mobility scenarios. Using the VIVE Pro Eye system, it is possible to simulate the

movement of pedestrians, cyclists, drivers, and public transport users under different infrastructure conditions, traffic volumes, lighting conditions, weather conditions, and traffic organization scenarios.

A major advantage of this device lies in its integrated eye-tracking technology, which enables real-time monitoring of users' gaze direction and visual attention. This is particularly important in research related to:

- traffic risk perception,
- analysis of drivers' visual attention,
- investigation of pedestrian and cyclist behavior,
- analysis of reactions in conflict situations,
- evaluation of traffic sign visibility and readability,
- safety research in intersection and pedestrian crossing areas,
- analysis of cognitive workload of traffic participants.

In the field of sustainable transportation, the VIVE Pro Eye can be especially useful for:

- simulation of traffic scenarios in virtual environments,
- analysis of traffic participant behavior,
- evaluation of infrastructure safety solutions,
- testing the organization of pedestrian and cycling flows,
- analysis of public space accessibility,
- investigation of interactions between different categories of road users,
- education and training in the field of traffic safety,
- visualization of planned transportation solutions,
- support for human factor research,
- development of VR applications for transportation and mobility.

3.1. Importance for Teaching

One of the primary goals of the Laboratory for Sustainable Transport is to improve the educational process through the use of modern technologies and interactive learning methods. The VIVE Pro Eye enables students to connect theoretical knowledge with realistic virtual experiences and analyze traffic situations in a controlled environment.

Instead of observing traffic situations only through photographs, videos, or diagrams, students can directly “enter” a virtual environment and analyze movement conditions from the perspective of pedestrians, drivers, cyclists, or public transport users. Such an approach significantly increases interactivity and improves understanding of complex transportation problems.

Students can learn:

- how VR systems are used in transportation analysis,
- how different traffic scenarios are simulated,
- how users’ visual attention is analyzed,
- how infrastructure safety is assessed,
- how different solutions are tested in virtual environments,
- how data obtained through eye-tracking technology are interpreted,
- how VR technology is applied in human factor and mobility research.

A particular advantage of this system is that it encourages the development of analytical and research-oriented thinking. Students can independently create scenarios, observe user behavior, analyze results, and propose measures for improving the safety and sustainability of transportation systems.

3.2. Examples of Student Activities

In teaching and laboratory exercises, the VIVE Pro Eye can be used for a wide range of practical activities.

Students can simulate pedestrian movement through intersections and analyze:

- which infrastructure elements pedestrians observe most frequently,
- how pedestrians react in conflict situations,
- whether traffic signs are sufficiently visible,
- whether there are elements that hinder orientation and movement.

It is also possible to simulate driving conditions and analyze:

- drivers’ visual attention,
- reactions to different traffic events,
- the impact of traffic signs and signals,
- reactions under reduced visibility conditions,
- the influence of infrastructure elements on safety.

The VR system can also be used to test infrastructure solutions before their implementation in real-world conditions. Students can analyze how different types of intersections, pedestrian zones, bicycle lanes, or public transport stops influence the movement and behavior of users.

This approach is especially important because it enables sustainable transportation to be studied not only theoretically, but also through interactive experiences and realistic scenario analysis.

3.3. Importance for Scientific Research

The VIVE Pro Eye can significantly improve scientific research in the fields of transportation, mobility, and human factors. Eye-tracking technology enables the collection of objective data related to users' visual attention and behavior, which is particularly important in traffic safety research.

The device can be useful in studies related to:

- driver behavior in virtual environments,
- analysis of pedestrian and cyclist reactions,
- risk assessment in conflict situations,
- attention and cognitive workload analysis,
- testing the readability and visibility of traffic signs,
- analysis of transportation infrastructure safety,
- development of VR models for education and training,
- research in sustainable mobility and human factors.

An important advantage of this system is that it enables safe testing of risky situations that would be difficult or unsafe to analyze in real-world conditions. At the same time, the virtual environment enables control of different parameters and repeatability of experiments, which is essential for scientific validity.

3.4. Importance for Sustainable Transportation and Intelligent Transport Systems

The VIVE Pro Eye represents an important tool in the process of digitalization and development of intelligent transport systems. Virtual reality enables the visualization and testing of different mobility concepts before their implementation in real environments.

In the field of sustainable transportation, VR technology can be useful for:

- testing urban mobility scenarios,
- analyzing interactions between pedestrians, cyclists, and motor vehicles,
- assessing public space accessibility,
- visualizing planned infrastructure solutions,
- analyzing traffic safety,
- education and awareness-raising regarding safe traffic behavior,
- development of digital models and simulations.

In this way, the VIVE Pro Eye is not only a VR device for virtual reality applications, but also a modern tool that connects education, research, digitalization, and sustainable transportation planning.

4. SOFTWARE FOR TRAFFIC SIMULATION AND ANALYSIS

Modern approaches to education, research, and professional practice in the field of transportation increasingly rely on the use of specialized software tools that enable the analysis, simulation, modeling, and visualization of complex transport processes. In the context of digitalization and the development of intelligent transport systems, the application of advanced software solutions has become essential for understanding spatial, infrastructural, safety-related, and technical aspects of transportation system operation.

Within the Laboratory for Sustainable Transport, several specialized software solutions will be used for the collection, processing, analysis, simulation, and visualization of various types of transportation-related data. Among the most important software tools are **PCA Software – Point Cloud Post-Processing Software**, intended for digital processing of spatial and LiDAR point cloud data, **ArcGIS Pro Basic**, a software platform for Geographic Information Systems (GIS) and spatial analysis, **PC Crash 15.0 Expert (3D)**, intended for traffic accident reconstruction, simulation, and safety analysis, and **ESI[tronic] Diagnostic Software**, which enables vehicle diagnostics and system analysis for modern vehicles, particularly electric and hybrid vehicles.

These software solutions have different but complementary functions. While PCA Software and ArcGIS enable the analysis of infrastructure, spatial characteristics, and transportation corridors, PC Crash provides the capability to simulate and analyze traffic events and safety risks, and ESI[tronic] enables the analysis of technical characteristics and conditions of modern vehicles. Their integrated application allows for a comprehensive understanding of the transportation system — from infrastructure and spatial organization to road user behavior, vehicle characteristics, and safety analysis.

In the context of sustainable transportation, these software tools make it possible to base transportation planning and management decisions on data, analysis, and simulation rather than solely on assumptions. In this way, they support more objective evaluations, more precise identification of transportation problems, and the development of more effective measures for improving safety, accessibility, energy efficiency, and mobility quality.

4.1. Importance for Teaching

One of the primary goals of the Laboratory for Sustainable Transport is to improve the educational process through the use of modern digital tools and interactive learning methods. The application of specialized software enables students to connect theoretical knowledge with real transportation problems and acquire competencies that are essential in contemporary professional practice.

Instead of studying transportation processes exclusively through formulas, diagrams, and theoretical concepts, students have the opportunity to work with real data, digital models, spatial visualizations, and simulations. In this way, they can directly analyze transportation infrastructure, examine spatial relationships, model traffic participant movements, analyze safety risks, and assess vehicle characteristics.

The use of these software tools enables students to learn:

- how spatial data are processed and visualized,
- how GIS tools are applied in mobility analysis,
- how transportation infrastructure is digitalized,
- how traffic events and accidents are simulated,
- how traffic risk factors are analyzed,
- how the results of spatial and safety analyses are interpreted,
- how diagnostic software is used for vehicle analysis,
- how professional reports, maps, visualizations, and analyses are prepared.

A particular value of this approach lies in the development of analytical and research-oriented thinking. Students are not only provided with ready-made solutions, but also learn how to collect data, analyze different scenarios, interpret results, and propose measures for improving transportation systems based on evidence and analysis.

4.2. Examples of Student Activities

In teaching and laboratory exercises, these software tools can be used for a wide range of practical activities directly related to modern transportation and mobility challenges.

Students can analyze spatial data obtained through LiDAR scanning, process point cloud data, and create digital models of streets, intersections, pedestrian zones, and transportation corridors. Based on such analyses, infrastructure

deficiencies can be identified, accessibility conditions can be evaluated, and possibilities for mobility improvement can be assessed.

By using GIS software, students can create thematic maps, analyze public transport accessibility, examine the connectivity of pedestrian and cycling networks, analyze traffic flow density, and identify high-risk zones.

Simulation software enables students to analyze different traffic event scenarios, examine the effects of speed, reaction time, infrastructure geometry, and traffic organization on safety levels. Through 3D simulations, it is possible to visually present the movement of traffic participants, reconstruct traffic accidents, and evaluate the possibility of avoiding hazardous situations.

Students can also analyze the technical characteristics of modern vehicles, especially electric and hybrid systems, examine the operation of sensors, electronic systems, and energy components, which is particularly important in the context of the development of electromobility.

Such activities enable students to acquire practical experience directly applicable to professional practice, while also developing competencies necessary for work in transportation planning, traffic safety, mobility management, and infrastructure digitalization.

4.3. Importance for Scientific Research

The application of specialized software has significant importance for scientific research in the field of transportation and traffic engineering. The ability to collect, process, visualize, and simulate data enables the development of research based on objective and measurable indicators.

These software tools can be used in research related to:

- transportation infrastructure analysis,
- traffic safety assessment,
- identification of hazardous locations,
- evaluation of pedestrian and cycling conditions,
- analysis of public transport accessibility,
- investigation of traffic participant behavior,
- simulation of traffic flows and accidents,
- analysis of electromobility and energy efficiency,
- development of GIS-based mobility models,

- creation of spatial databases,
- development of sustainable mobility indicators,
- analysis of the impact of infrastructure on safety and accessibility.

These software tools can be used in the preparation of scientific papers, master's theses, student projects, professional studies, and other research activities. Their particular value lies in the fact that they provide a high level of objectivity, as analysis results can be measured, visually presented, and repeatedly tested.

4.4. Importance for Sustainable Transportation and Intelligent Transport Systems

The modern concept of sustainable transportation involves the application of technologies that enable safer, more efficient, more accessible, and environmentally friendly movement of people and goods. In this context, the application of specialized software plays a crucial role, as it enables transportation systems to be analyzed as integrated systems based on data, models, and simulations.

The software tools used in the laboratory enable the digitalization of transportation infrastructure, spatial analysis, simulation of transportation processes, safety assessment, mobility analysis, and monitoring of technical characteristics of modern vehicles. Based on the obtained results, it is possible to develop measures that contribute to reducing traffic risks, improving public space accessibility, optimizing transportation routes, achieving more efficient mobility management, and increasing the energy efficiency of transportation systems.

A particularly important advantage of these software solutions lies in their ability to integrate different types of data and analyses into a unified decision-support system. Spatial data, traffic simulations, infrastructure analyses, safety indicators, and vehicle-related data can be combined to provide a more comprehensive understanding of transportation system performance and to identify the most effective improvement measures.

In this way, these software tools represent an important foundation for the development of Intelligent Transport Systems (ITS), as they enable the application of digital technologies, spatial analysis, simulation models, and real-time data in transportation planning and management. At the same time, they contribute to the modernization of education, the advancement of research, and the development of professional competencies necessary for planning and managing sustainable mobility in the future.



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5. DRIVING SIMULATOR

The driving simulator, acquired through the Erasmus+ TRAFSAF project, represents one of the most important tools for studying driver behavior, analyzing hazardous situations, and providing education in the field of traffic safety. Its application is directly linked to the concept of sustainable transportation, as safety represents one of the fundamental prerequisites of sustainable mobility. A transportation system associated with a high level of risk, traffic crashes, and injuries cannot be considered sustainable, regardless of its environmental, economic, or technological characteristics.



Figure 2. Driving Simulator

The simulator enables the investigation of driver behavior in controlled laboratory conditions without exposing participants to real risk. This approach is particularly important because it allows the analysis of situations that would be dangerous, unpredictable, or ethically unacceptable to test in real traffic conditions. For example, it is possible to simulate the sudden appearance of pedestrians, abrupt braking of vehicles ahead, driving under reduced visibility, adverse weather conditions, driver fatigue, speeding, distracted driving, or movement near schools, pedestrian crossings, and intersections.

Within the context of the Laboratory for Sustainable Transport, the driving simulator enables the analysis of driver responses to different infrastructure solutions and traffic management measures. It is possible to examine how drivers react to traffic calming measures, speed limit zones, roundabouts, bicycle lanes,

pedestrian areas, public transport systems, and different traffic organization scenarios. In this way, it becomes possible to assess the potential effects of specific measures before their implementation in real-world environments.

A particular advantage of the simulator lies in the possibility of repeating identical scenarios with a larger number of participants. This enables comparisons among different categories of drivers, such as young drivers, experienced drivers, professional drivers, or drivers with varying levels of risky behavior. Such an approach is highly valuable for scientific research because it enables systematic collection of data related to reaction time, travel speed, braking intensity, path selection, maintenance of safe following distance, compliance with traffic regulations, and decision-making in critical situations.

5.1. Importance for Teaching

One of the primary goals of using the driving simulator is to improve the educational process through a practical and interactive approach to studying traffic safety and the human factor. Students are given the opportunity to connect theoretical knowledge with realistic scenarios and directly observe how different factors influence driver behavior.

Instead of studying driver behavior exclusively through literature, statistical data, and theoretical models, the simulator allows students to actively participate in the analysis of specific traffic situations. They can observe the effects of speed, infrastructure, visibility, traffic density, weather conditions, and the behavior of other road users on decision-making processes during driving.

Students can learn:

- how driver behavior is analyzed under different conditions;
- how infrastructure influences traffic safety;
- how different traffic management regimes affect road user behavior;
- how risky traffic situations are assessed;
- how reaction time and decision-making are analyzed;
- how the effects of traffic calming measures are evaluated;
- how human factor analysis is conducted in transportation.

A particularly important educational value of the simulator lies in the fact that it enables students to experimentally test different scenarios and independently draw conclusions regarding the factors affecting transportation safety and sustainability.

5.2. Examples of Student Activities

In teaching and laboratory exercises, the driving simulator can be used for a wide range of practical activities.

Students can investigate:

- driver reaction time under different conditions;
- the behavior of young and inexperienced drivers;
- the effect of speed on the possibility of avoiding crashes;
- driver reactions near schools, pedestrian crossings, and intersections;
- driver behavior toward pedestrians and cyclists;
- the effects of traffic calming measures;
- driving behavior under reduced visibility and nighttime conditions;
- the impact of driver distraction during vehicle operation;
- reactions in adverse weather conditions;
- different traffic conflict and risk scenarios.

In addition to individual analyses, students can compare results among different groups of participants, analyze collected data, and propose measures for improving traffic safety. Such activities allow students to connect theoretical knowledge with practical experience and develop analytical approaches to solving transportation problems.

5.3. Importance for Scientific Research

The driving simulator has significant application in scientific research, particularly in the areas of human factors, traffic safety, and driver behavior. The possibility of controlling experimental conditions and repeating identical scenarios enables the collection of objective, comparable, and measurable results.

The simulator can be useful in research related to:

- analysis of driver reaction time;
- assessment of the impact of speed on safety;
- analysis of the effects of fatigue, stress, and distraction;
- research on the behavior of young and high-risk drivers;
- analysis of driver interactions with pedestrians and cyclists;
- evaluation of the effects of different infrastructure solutions;
- assessment of safety in school zones and pedestrian crossings;

- analysis of behavior under reduced visibility conditions;
- testing of different traffic management measures;
- research in sustainable and safe mobility.

A major advantage of the simulator lies in the possibility of investigating risky situations without exposing participants to danger. At the same time, the controlled environment ensures experiment repeatability, which is particularly important for scientific validity and comparison of different scenarios.

5.4. Importance for Sustainable Transportation and Intelligent Transport Systems

The driving simulator plays an important role in the development of sustainable transportation and intelligent transport systems, as it enables testing and evaluation of different transportation measures before their implementation in real-world environments. In this way, it becomes possible to assess potential risks, the effects of infrastructure changes, and the influence of different traffic management strategies on safety and mobility.

In the context of sustainable transportation, the simulator contributes to understanding how drivers respond to new infrastructure forms, speed restrictions, pedestrian and cycling facilities, public transport systems, and traffic calming measures. This makes it possible to design transportation systems that are safer, more accessible, and more efficient for all road users.

More broadly, the simulator supports a preventive approach to traffic safety. Instead of analyzing traffic crashes only after they occur, potential risks can be identified in advance, different measures can be tested, and the likelihood of negative outcomes can be reduced. In this way, the simulator represents an important tool for integrating education, research, prevention, and the development of smart and sustainable mobility.

6. TRAFFIC RECORDING DEVICES

Within the Laboratory for Sustainable Transport, traffic recording devices play an important role in documenting, analyzing, and monitoring various aspects of transportation systems under real-world conditions. The equipment acquired through the Erasmus+ PELMOB project represents an important resource for field research, traffic flow analysis, safety assessment, and monitoring of mobility characteristics.

For the purpose of traffic recording and analysis, the laboratory uses the **GoPro Hero11 Black action camera**, intended for recording traffic situations from a close-range and dynamic perspective, as well as the **DJI Mavic 3 Fly More Combo drone**, which enables aerial recording of transport infrastructure, spatial analysis, and monitoring of traffic flows from above.

The application of these devices enables the collection of visual data that can be used to analyze the behavior of traffic participants, monitor infrastructure performance, identify hazardous situations, analyze traffic conflicts, and develop measures for improving traffic safety and transportation sustainability. Their particular importance lies in the possibility of recording real traffic situations under different temporal, spatial, and infrastructural conditions, thus providing data based on actual road user behavior.

6.1. Importance for Teaching

One of the primary goals of applying traffic recording devices is to improve the educational process through a practical and interactive approach to the study of transportation, mobility, and traffic safety. Instead of analyzing traffic situations exclusively through photographs, diagrams, or theoretical examples, students can work with real-world recordings obtained in the field and directly analyze the actual behavior of traffic participants.

The GoPro camera enables recording from the perspective of drivers, cyclists, or pedestrians, allowing students to conduct detailed analyses of conflicts, user reactions, and the influence of infrastructure on behavior. On the other hand, the drone provides a broader spatial perspective of the functioning of intersections, transport corridors, pedestrian zones, cycling infrastructure, and public transportation systems.

Students can learn:

- how traffic situations are recorded and documented;
- how traffic flows are analyzed;
- how conflict situations and risks are identified;
- how infrastructure affects the behavior of road users;
- how pedestrian and cycling facilities are evaluated;
- how visual analysis of transportation problems is conducted;
- how collected recordings are used in transportation research and planning.

A particular value of this educational approach lies in the fact that it enables students to connect theoretical knowledge with real-world situations while developing critical observation and transportation analysis skills.

7.2. Examples of Student Activities

In teaching and laboratory exercises, traffic recording devices can be used for a wide range of practical activities.

Students may conduct:

- recording of traffic flows at intersections;
- analysis of pedestrian behavior at pedestrian crossings;
- monitoring interactions between drivers, pedestrians, and cyclists;
- analysis of traffic conflict situations;
- recording of school zones and traffic calming areas;
- analysis of compliance with traffic regulations and signs;
- assessment of cycling infrastructure safety;
- analysis of public space accessibility;
- monitoring public transportation performance;
- aerial recording and analysis of transportation corridors;
- preparation of spatial representations of infrastructure;
- time-lapse analyses of traffic conditions over time.

Using the action camera, students can record detailed traffic situations from a close perspective, while the drone enables analysis of the broader spatial context, traffic density, and traffic organization. By combining data obtained through these devices, it becomes possible to achieve a more comprehensive understanding of transportation system performance.



Figure 3. Action Camera for Traffic Recording



Figure 4. Drone for Traffic Recording

6.3. Importance for Scientific Research

Traffic recording devices have significant application in scientific research because they enable systematic collection of visual and spatial data under real traffic conditions. The collected recordings can be used to analyze road user behavior, identify hazardous situations, assess infrastructure safety, and evaluate spatial characteristics of transportation systems.

These devices may be used in research related to:

- traffic flow analysis;
- traffic risk assessment;

- investigation of pedestrian, cyclist, and driver behavior;
- analysis of traffic conflict situations;
- assessment of intersection and pedestrian crossing safety;
- analysis of infrastructure impacts on mobility;
- research on active mobility;
- monitoring changes in transportation environments;
- accessibility analysis;
- GIS and drone-based spatial analysis;
- transportation infrastructure monitoring.

A major advantage of these devices in research lies in the possibility of repeated recording of the same locations and situations, which enables monitoring changes over time and comparing the outcomes of different transportation interventions.

6.4. Importance for Sustainable Transportation and Intelligent Transport Systems

Traffic recording devices represent an important instrument in the development of sustainable transportation and Intelligent Transport Systems (ITS), as they enable the collection of data necessary for understanding transportation system performance and supporting evidence-based decision-making.

By using action cameras and drones, it becomes possible to analyze real mobility conditions, assess infrastructure safety, monitor pedestrian, cycling, and public transport systems, and identify problems affecting mobility and safety. These devices enable the visualization of spatial transportation problems, monitoring of traffic flows, and testing of different infrastructure solutions.

Their importance is particularly evident in the field of active mobility, as they enable the analysis of walking and cycling conditions, identification of spatial barriers, monitoring of conflict situations, and assessment of public space accessibility. At the same time, aerial recording provides a more comprehensive understanding of traffic organization, spatial relationships, and transportation infrastructure capacities.

In the context of Intelligent Transport Systems (ITS), these devices represent an important source of data for infrastructure digitalization, spatial analysis, traffic monitoring, and the development of measures aimed at creating safer, more efficient, and more sustainable transportation systems. In this way, they contribute

to the integration of teaching, research, and practical applications in the field of modern transportation.

CONCLUSION

The laboratory manual represents a significant outcome of activities implemented within the **Erasmus+ SPHERE project**, with the primary objective of improving teaching, scientific research, and the practical application of knowledge in the field of sustainable transportation and mobility. Its main purpose is to provide users with a systematic overview of laboratory equipment, software, and devices, as well as the possibilities for their application in education, research, and professional practice. Through the description of modern technologies, methods of measurement, recording, simulation, spatial analysis, and digital data processing, the manual connects theoretical knowledge in the field of transportation and traffic engineering with practical approaches to transportation system analysis.

Modern transportation systems require an integrated, data-driven, and technology-supported approach to planning, management, and mobility improvement. For this reason, laboratory equipment and software represent important tools for understanding the complex relationships between infrastructure, traffic participants, vehicles, the environment, and traffic management measures. Instead of relying solely on theoretical assumptions, the application of modern technologies enables the collection of real-world data, analysis of spatial characteristics, simulation of different traffic scenarios, risk assessment, and visualization of the effects of various measures before their implementation in real environments.

The particular value of the laboratory infrastructure lies in its ability to support practice-oriented education. Through the use of modern equipment and specialized software, students acquire knowledge and skills that go beyond the scope of traditional classroom teaching. They have the opportunity to participate in field research, analyze spatial and traffic-related data, use GIS tools, apply simulations, investigate human factors and traffic safety, and assess various aspects of mobility and infrastructure. Such an approach contributes to the development of analytical thinking, critical problem-solving skills, and evidence-based decision-making abilities.

The application of equipment and software is of particular importance in the field of **sustainable transportation**, as it enables a comprehensive understanding of mobility, accessibility, safety, and environmental protection challenges. Walking, cycling, public transportation, and other forms of sustainable mobility can be analyzed through specific indicators and spatial conditions, while simulations and

digital analyses enable the testing of different scenarios prior to their implementation. In this way, sustainable transportation does not remain merely a theoretical concept, but becomes a practical framework for developing safer, more efficient, and more accessible transportation systems.

In addition to its educational role, the laboratory also possesses considerable scientific and research potential. Equipment and software can be used to conduct various studies related to traffic safety, urban mobility, active transportation, infrastructure digitalization, spatial analysis, intelligent transport systems, and the behavior of traffic participants. The results obtained through the application of laboratory resources may serve as the basis for seminar papers, final and master's theses, scientific publications, professional studies, and projects aimed at improving transportation systems and supporting local communities.

An important aspect of this manual also lies in promoting an **interdisciplinary approach**, as sustainable transportation integrates transportation engineering, urban planning, traffic safety, information technologies, geographic information systems, data analysis, environmental protection, and public policy. Working with laboratory equipment enables the integration of these disciplines through practical tasks and research activities, thereby creating conditions for a more comprehensive understanding of transportation systems and contemporary mobility challenges.

In essence, this laboratory manual represents more than a technical guide for the use of equipment. It provides a foundation for the development of a modern educational and research model in transportation, in which knowledge is acquired through practical work, analysis, experimentation, and the application of advanced technologies. Through the integration of equipment and software acquired within Erasmus+ projects, conditions are created for strengthening institutional capacities, modernizing education, and developing professionals capable of addressing the challenges of safe, smart, and sustainable mobility in the future.



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