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Editor's note

The specialized supplement "Applied Research Topics in Transport and Logistics" is a new publication issued bilingually in conjunction with the influential international scientific journal, "Promet – Traffic&Transportation".

The scientific journal "Promet – Traffic&Transportation", published by the Faculty of Transport and Traffic Sciences since 1989, is indexed in citation databases such as Web of Science (SCIE), Scopus, TRID and GEOBASE. Over the last decade, the journal has experienced a continuous increase in impact factors, reaching 1.0 in the year 2022. We publish outstanding scientific achievements from international authors. Additionally, in 2022, the journal was classified in the second quartile (Q2) according to the citation database Scopus, marking a significant success at the international level.

The publication of this specialized supplement is part of the ongoing modernization actively pursued by the editorial board of "Promet – Traffic&Transportation". Through this effort, we aim to bring scientific achievements in the field of transportation and logistics closer to the business community, influencing awareness about current issues and enhancing the competitiveness of our companies in the market.

The specialized supplement "Applied Research Topics in Transport and Logistics" focuses, in its inaugural edition and future editions, on addressing topics targeted at economic interest groups in the field of transportation and logistics. It is designed primarily to facilitate communication and correlation between science and industry, focusing on bridging and presenting scientific practices and achievements in the economy. The key focuses of this supplement are:

- *Current topics in transportation and logistics*
- *Presentation of laboratories and research groups in the field of transportation and logistics*
- *Showcasing current projects and conferences in the field of transportation and logistics*
- *Updates in the field of transportation and logistics*

This supplement also introduces fellow researchers, individuals and companies through interviews, research comments and other forms of text of interest and necessity. It focuses on presenting companies from the economy to strengthen their position in the competitive markets of Croatia and the EU.

The specialized supplement is international, issued with the support of partner institutions of the journal "Promet – Traffic&Transportation" (Univerza v Ljubljani – Fakulteta za pomorstvo in promet, Univerza v Mariboru – Fakulteta za logistiko, Budapest University of Technology and Economics),

which support the project of issuing the specialized supplement and also participate in preparing topics and presenting their research groups, aiming to showcase to the EU community.

The themes of this first edition in 2024 focus on issues related to warehouse automation, which poses a significant operational and financial challenge to the logistics industry, challenges in waste management, road safety and the presentation of the professional initiative of the startup "CikloParking". Additionally, we will guide you through various events in our field, such as the excellent recently held international scientific conference "ZIRP (Science and Development of Transport)" organized by the Faculty of Transport and Traffic Sciences at the University of Zagreb, and the international scientific conference of very interesting and special subject matter, "Logistics in Agriculture", held at the Center for Biotechnology and Tourism Grm Novo Mesto in Slovenia. In the first edition, we also introduced an excellent project model called Transportikum, which focuses on connecting scientific institutions with the economy in a truly unique way.

I hope you will find topics of interest for yourselves, and together, through this specialized supplement, we will bring science closer to practice in this highly dynamic and competitive field of transportation and logistics!

Ivona Bajor, Editor-in-Chief

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01

AUTOMATION of Warehouse System



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The automation of warehouse systems and the implementation of advanced technologies into existing logistic systems pose operational and financial challenges. The decision-making process regarding the level of automation is strategically planned and depends on numerous criteria. The author of the text, Prof. Kristijan Rogić, Ph.D., Head of the Department of Transport Logistics at the Faculty of Transport and Traffic Sciences, provides insights into making these relevant decisions in planning the future of business operations.

1. Introduction

The warehouse system is one of the key elements of the supply chain. Many elements of the logistics and distribution system depend on it and the efficiency of processes within the warehouse can positively or negatively impact the overall efficiency of the supply chain. The challenges in logistics today are complex: flows of goods and market demand are increasing, energy and raw material prices are rising, the product lifecycle is getting shorter and the product range is very wide. In developed countries, there is a constant need for labor, particularly pronounced in the logistics sector, especially in transportation and storage. Land prices and rental costs are on an upward trend, affecting decisions on the construction or expansion of logistic capacities. Additionally, new solutions for improving logistics systems, relying on Industry 4.0 technological solutions, continuously emerge in the market, with applications in various segments of logistics activities.

The significant growth of e-commerce has forced warehouse operators to adopt advanced technologies to more effectively address the challenges of real-time tracking, processing and timely delivery of packages. Apart from traditional distributors, online retailers are now incorporating various forms of

automation in their warehouses to enhance order fulfillment, improve warehouse processes and reduce the percentage of faulty shipments. This is done to minimize delivery costs and remain competitive in the online market [1].

In this context, the automation of warehouse systems encompasses a range of diverse technical approaches and technological solutions. Its primary goal is to increase the efficiency of warehouse processes, enhance the organization of warehouse operations, optimize the utilization of warehouse space and stabilize labor force demand.

Automation of warehouse systems can be defined as the organization of the movement of goods within a warehouse through the use of various automated solutions, with limited reliance on human labor.

The automation of warehouse systems can be implemented at two levels [2]:

- Automation of decision-making processes
- Automation of goods handling systems

The decision-making process involves managing data to improve warehouse processes, optimize the use of available resources and enhance systems for storing and picking goods.

Handling goods involves selecting and implementing optimal solutions for manipulating goods within

a warehouse, utilizing mechanized or automated systems.

In some cases, system automation involves the introduction of advanced machinery or autonomous robotics, while at a lower level, it may also entail implementing advanced computer systems for warehouse management.

2. Types and division of automated warehouse systems

Automation of processes in warehouses can be divided into several levels depending on the extent of application of automated solutions and the concept of warehouse system organization. Warehouse systems, based on the criterion of process automation, are divided into the following groups:

- Manual Warehouses
- Low-Automation Warehouses
- Automated Warehouses
- High-Automation Warehouses.

Manual warehouses are those where processes rely on human labor and computerized warehouse management systems (WMS) are used as information tools. Low-automation warehouses use systems that facilitate the connection between operators and a computer system managing operators and processes, such as Voice picking, Pick by light or Pick to light. In automated warehouses, processes involve a combination of low human labor and automated systems, primarily in the collection and storage of goods (AS/RS, multicarousels, VLM systems, etc.). In high-automation warehouses, the proportion of human labor is minimal, and all warehouse processes, including receiving goods and preparing shipments, are automated and connected through a Warehouse Management System (WMS) or Warehouse Execution System (WES).

2.1. Reasons for warehouse automation

The reasons influencing the decision to automate warehouse systems depend on the characteristics of each warehouse system. There are no universal criteria applicable to the automation process; it depends on the specific needs and challenges of each system. For instance, in some cases, a crucial criterion may be the lack of or fluctuation in the workforce, while in other situations, the issue could be a shortage of space.

In general, the most important reasons for implementing automated systems in warehouses are as follows:

- Reduced dependence on workforce fluctuations and shortages
- Decreased overall labor costs

- Increased efficiency in warehouse system performance
- Better space utilization
- More effective inventory management
- Ability for long-term planning of required capacities and resources

The selection of an automated system solution is therefore tailored to the specific needs of each client, depending on the characteristics of logistics and warehouse processes. The proposed solution depends on the item structure, expected system capacity, available warehouse space, anticipated benefits from the introduction of automated technology and the available budget. Additionally, an important element in the process of selecting automated systems is the expected return on investment (ROI). Based on practical experience, the most common reasons for implementing automated systems include labor shortages, the potential for increased storage density (warehouse space utilization) and the planning of warehouse system performance.

2.2. Overview of features of commonly used automated systems

The prevalence of automated warehouse system implementation is not uniform. It often depends on warehouse capacities, the expected number of warehouse operations, the purpose of the warehouse, the cost and the availability of a particular solution.

The most commonly used automated systems in warehouses are the following:

- Voice-directed picking (Pick by voice)
- Light-directed picking (Pick by light)
- AGV (Autonomously Guided Vehicles)
- AS/RS systems (Automated Storage and Retrieval Systems)
- Multicarousels (AutoStore and related systems)
- Autonomous Mobile Robots (AMR)

One of the most significant advantages of voice-directed picking (Voice Picking) is ensuring the hands and eyes of the operator are free. When hiring seasonal workers, the number of training days has a significant impact on choosing the appropriate picking method. A worker can transition from a traditional picking system to a voice picking system in 1 to 2 days without additional time spent on training. [3] Research conducted so far suggests that voice picking provides an additional level of efficiency, minimizing errors. Warehouse processes influenced by pick by voice are mainly picking, receiving and storing, while its utilization is possible in almost any warehouse process. The benefits of implementing voice picking include the following [4]:

- Increased accuracy: Reducing errors in picking is

one of the most significant advantages of voice picking, although the error rate in conventional systems is up to 0.5% of orders.

- Increased productivity: Operators have free hands, can more easily concentrate on their surroundings and have unrestricted movement.
- Cost reduction: Among other things, there are no costs for printing and creating picking lists.
- Short training period: Verbal instructions are easier to understand and the worker can quickly learn all commands in a short time.

Pick-by-Light is a stationary system based on signal lights. Classical pick-by-light systems are usually designed for picking items into boxes or smaller transport units. Besides logistics systems, this concept is also used in manufacturing systems [5]. The Pick-by-Light concept is very similar to the Pick-by-Voice system, and therefore, the expected benefits are almost the same. The main difference between these concepts is that the Pick By Light system requires infrastructure mounted on shelves (light indicators and displays), making this technology more challenging to implement on existing infrastructure.

AGV belongs to the class of highly flexible, intelligent and versatile robotic handling systems used for transporting materials to various locations within a facility. They utilize modern microprocessor

technology to guide the vehicle along a predetermined path and have the capability to correct the course if the vehicle deviates from the intended path. The system controller receives instructions directly from the main computer, communicates with other vehicles and issues appropriate commands to each vehicle. To avoid collisions, communication between AGVs is essential. Vehicle guidance technologies vary, with common solutions being floor guidance or guidance through radio communication [6]. There are different types of automated guided vehicles that can meet various service requirements. Types of vehicles include:

- Tow vehicles (Figure 1)
- Unit load carriers
- Pallet forklifts
- Forklifts
- Light load carriers
- Assembly line vehicles

The control systems of AGVs enable automatic positioning of the vehicles and manipulation of goods. Current generations of AGVs can integrate with Automated Storage and Retrieval Systems (AS/RS) and operate in a traditional manual system. They are also capable of bidirectional travel along the same path and real-time resource allocation under computer control [6].

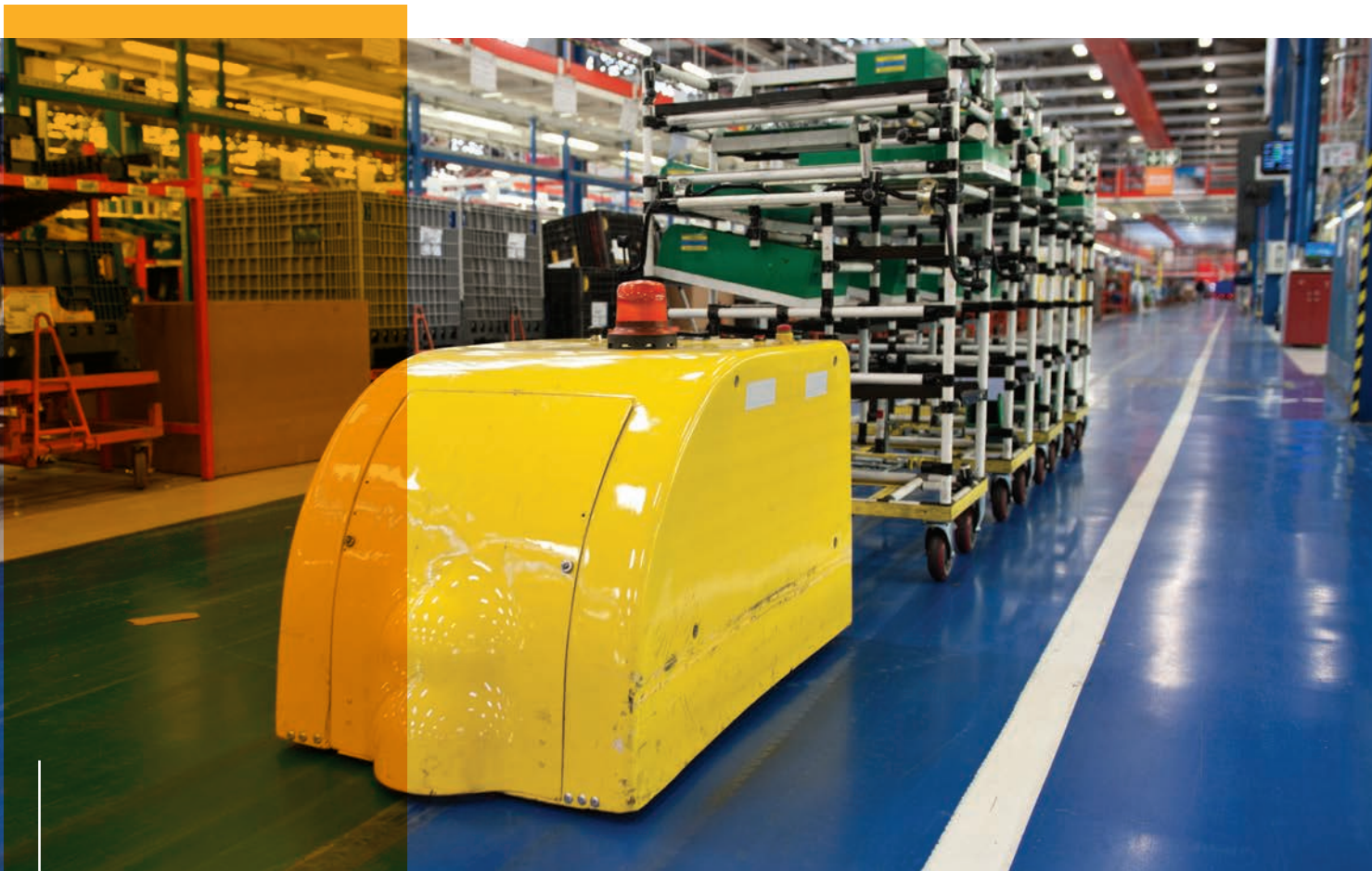


Figure 1: AGV Tow Vehicle

The global AGV market was valued at 3.89 billion USD in 2018 and is estimated to reach 10 billion USD by 2024. In addition to their application in industrial and logistics systems, AGVs can also be used for luggage transport in airports, assisting people with disabilities, food and medicine delivery, bomb and mine mapping, locating and disposing of nuclear products, facility inspections and similar activities, making them highly flexible and versatile [7].

The basic idea of Automated Storage and Retrieval Systems (AS/RS) is to accelerate two key warehouse operations that have the most significant impact on overall storage efficiency: storing goods and picking. There are different implementations of automated storage and retrieval systems, depending on the type of storage units they are designed for. A common element in all systems is computer control. The computer managing the system, using algorithms, determines where goods will be stored in the warehouse space, from which position a specific storage unit will be picked and the sequence of picking. The AS/RS management system is also connected to the Warehouse Management System (WMS), enabling the tracking of the quantity and status of stored goods in the warehouse.

Construction-wise, an AS/RS system consists of a series of storage locations (Figure 2) tailored to the dimensions of storage units. The system is composed of blocks with a specific number of storage locations. Each block is equipped with a handling device (for storage/retrieval) that moves vertically and horizontally along the block.

Automated storage and retrieval systems do not require significant upfront investments in infrastructure. Maintaining such systems involves training staff and gaining expertise. Each AS/RS system requires software support, faces variable demands, the need for maintenance, aging technology and mechanization fatigue. The cost of acquiring and implementing an efficient automated system is substantial and encompasses all segments of the supply chain. The experience of companies using AS/RS systems also indicates significant ongoing costs for maintenance and updating various subsystems.

The installation of AS/RS system is technologically justified in the following circumstances [9]:

- Warehouse operations in two (minimum) or three shifts
- Low to critical stock levels
- Production flexibility
- Joint storage of finished products and semi-finished goods
- High land cost where the warehouse is built (greater potential for savings)
- No legal restrictions on building height
- Capability for effective system maintenance
- Higher value per unit of product
- High frequency of input-output operations and item turnover
- Need for larger storage capacity
- Possibility to adapt warehouse space for system installation.

Automated storage systems are applicable in distribution and industrial (manufacturing) warehouses.

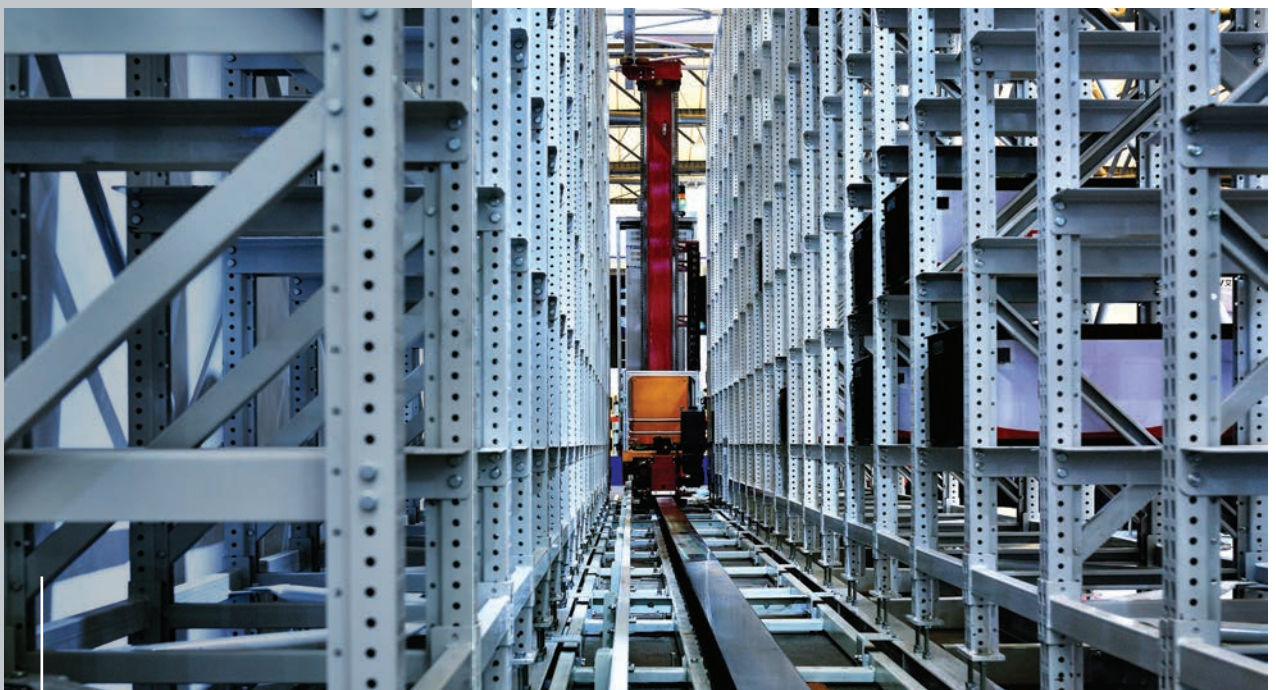


Figure 2: Structure of AS/RS system



• *Figure 3: Mobile robots of the multicarousel system*

In manufacturing warehouses, automated storage systems are used for storing components and semi-finished products and are integrated with the production line. This significantly increases the efficiency of the manufacturing process [8].

A carousel is an automated storage device that offers streamlining of warehouse operations, especially when the storage space is relatively low, narrow and long. Compared to traditional goods-to-person systems (e.g., gravity racks or shelves), the use of carousels enables the application of the “goods to person” principle with minimal operator movement, the ability to optimize the order of picking items and a high level of operator efficiency. The modular design of the device allows adaptation to space or goods, i.e., the required capacity. Carousels can be divided into three categories based on the way they move (retrieve) goods: horizontal, vertical and multicarousels (an implementation that uses robots with both vertical and horizontal movements to retrieve goods).

A horizontal carousel consists of sections (containers for goods) that rotate in a horizontal plane and are interconnected via an articulated arm, forming an “infinite” chain. Using electric motors, the sections can be moved forward or backward to a station with a picker.

Features of a horizontal carousel include:

- Fast access to goods due to the “goods to person” concept, expected capacity of 200–400 retrievals per hour/operator

- Batch-picking capability
- A fully enclosed device prevents any unauthorized access to both the device and stored goods
- Simultaneous operations of several horizontal carousels increase the efficiency of goods storage
- Computerized control of the device brings specific items to the working opening – knowledge of the types of goods is not necessary
- Utilizes the available building space
- High level of space utilization
- Ability to connect and synchronize multiple carousels

Vertical carousels operate based on the movement of shelves in the vertical plane, optimizing the shortest route in both directions. They utilize the vertical component of the storage space, allowing for high space utilization. They can be configured as a series of devices, increasing their capacity and picking efficiency.

Features of vertical carousels:

- Existing room height is utilized from “floor to ceiling” – efficiency up to 80%
- Goods come to the operator in the shortest possible time (higher handling speed) – increased productivity
- Physical labor reduced to a minimum (ergonomically designed openings) – increased accuracy
- Stored goods are protected from dust, dirt and unauthorized access
- Possibility of installing devices across multiple floors.

Multicarousels enable the retrieval of items using mobile robots (Figure 3) that have the ability to move horizontally and vertically access containers. Containers are arranged vertically and items are located within these containers. Each container can contain one or more items. The system is computer-controlled. Containers are arranged according to ABC categorization principles, allowing for a high level of system performance. Container dimensions are standardized. Along with high performance, the use of such solutions achieves high space utilization in the warehouse. It is possible to expand them as needed by adding storage locations or increase efficiency by adding robots or picking stations. The system's limitation is related to the dimensions and weight of items that can be stored in the container. One of the most well-known systems in use is AutoStore, produced by the manufacturer of the same name. In recent years, there has been a significant increase in the implementation of such systems for various categories of goods.

AMRs are a newer and more advanced version of AGVs. They are more sophisticated, efficient, faster, smarter and easier to deploy. They can operate without any accompanying infrastructure such as precisely located laser targets, wires or magnets embedded in the floor. They have the ability to map and navigate around obstacles with human-robot interface. They consist of powerful laser sensors based on artificial intelligence (AI) technology, sophisticated camera systems and computer hardware, allowing them to work and move dynamically using a map of their environment. They are not limited to fixed routes; they can plan and optimize their movement route for better performance. AI technology transforms AMRs into intelligent devices that can identify other machines and react to their presence, including forklifts, vehicles, people and other material handling equipment, allowing them to work safely in their environment. AMRs also have advanced capabilities such as tracking a specific person. AMR systems are cost-effective and scalable for future expansions. AMRs are commonly divided into two types:

- Fleet Management Technology-based AMRs, where routing systems guide robots from the starting point to the destination. They are designed to work with larger transfer units.
- Order Picking Optimization-oriented AMRs (Image 4) – robots in this category are used to increase picking efficiency by reducing the movement of operators. This type of robot is primarily intended for working with smaller storage units (picking into cardboard boxes, plastic containers, etc.) [1].

3. Application of automated systems in warehouses

Automated storage and retrieval systems can be utilized in both industrial and distribution warehouses. Available technologies are applied to accommodate various item formats and a wide range of required input or output capacities. However, due to substantial initial investments and expected return on investment timelines, automated systems are commonly employed in warehouses with a larger number of items (more than 1,000) and a significant volume of input and output manipulations.

According to the criterion of application concerning the type of warehouse process, automated systems are most commonly applied in the picking process. It is known that the picking process consumes the largest share of resources and time, and consequently, costs compared to other warehouse processes (up to 55%), hence the understandable need for its optimization. Automated systems contribute to improving the picking process by reducing the time needed to gather items, increasing the efficiency of individual operators, achieving a higher level of order accuracy and enhancing storage density. Additional benefits include reduced labor costs, increased safety levels and more effective management of storage locations and inventory due to the application of Warehouse Control Systems (WCS). The numerical values for each of these indicators vary and depend on the values of performance indicators before the introduction of automated systems. Generally, improvements range from 10% to 40%, depending on the observed indicator and the initial values of the indicators. In other segments of the warehousing



process, the application of automated systems is less pronounced, but even in those segments, developed systems and technologies allow for higher efficiency and better performance indicators.

Regarding working conditions, automated warehouse systems can be applied in various storage regimes. They are most commonly used in ambient warehouses; however, their application is also possible in conditioned storage regimes and warehouses for frozen goods. The application of automated systems in warehouses is desirable from the perspective of safety and human health, even in warehouses with goods that may be harmful to health (e.g., warehouses for radioactive substances).

3.1. Methodology for selecting automated systems

Considering that there is a large number of technological solutions in the field of automated warehouse systems, selecting the technology that best suits the needs of a particular entity is a complex process. The successful implementation of automated systems, therefore, involves several phases:

- Defining objectives
 - Analyzing warehouse processes and item structures
 - Analyzing features of existing technologies
 - Developing a technological concept
 - Reviewing available technologies
 - Selecting potential suppliers
 - Defining technical and technological procurement conditions
 - Procurement, assembly and system implementation
- Defining objectives is related to selecting the most

significant improvements to be achieved by introducing automated systems. This often involves reducing dependence on labor, cutting operational costs, achieving a higher level of service, improving system performance and optimizing the use of available warehouse space (increased storage density of storage units). During this phase, an approximate budget and the expected return on investment period can be defined.

The analysis of warehouse processes and structure involves a detailed review of the existing system organization, including an examination of performance indicators and critical points in individual processes. The structure of items refers to the analysis of the share of individual items in total turnover (ABC analysis) and the characteristics of items (dimensions, weight, common packaging methods, required storage conditions, etc.). The elements that should result from this preparatory phase are as follows:

- Defining the required level of system flexibility
- Analyzing the demand structure: the level of demand variability (seasonality, peak demand periods)
- Identifying processes or parts of processes with pronounced repetitive activities
- Defining the expected growth/volume of business in the next medium-term period
- Listing the technical and technological features of existing IT and other technologies applied in warehouse operations

In the phase of developing the technological concept, based on the analysis of processes, product structure, spatial requirements and constraints, as well as the structure of processes, possible technological solutions are proposed. The final phase of developing the technological concept includes a proposal with an initial configuration and features, along with a rough estimate. Such a proposal serves as the basis for creating tenders (cost estimates) and initiating the procurement process.

This phase of introducing automated systems can be carried out independently or in collaboration with a partner specializing in the analysis in this field.

The end result of the mentioned process is the implementation of a system that should meet the business requirements in the mid-term period, i.e. at least during the return on investment period.

Regarding the type of process, the implementation of automated warehouse systems is most often associated with the automation of a part of the warehouse processes, with a focus on improving the order-picking system. This is because the order-picking process is organizationally the most demanding



Figure 4: AMR picking system

compared to other warehouse processes and its realization requires a significant portion of labor and mechanization. Therefore, improvements in the order-picking process have the most significant impact on the overall performance of the warehouse system.

Technological solutions available on the market are also largely associated with the improvement of the order-picking process for the same reasons.

3.2. Review of the market of automated warehouse systems in Croatia

The first systematic research on the state and structure of the warehouse capacity market in Croatia was conducted for the needs of the Logistics in the Republic of Croatia study [10] (period 2019–2020), where data on the characteristics of warehouse capacities and equipment were collected. The data were collected from the most important logistics operators in the Croatian market.

According to the mentioned research, in the warehouse capacity segment, distribution warehouses, including large distribution centers, dominate (90% of the sample). Some warehouse capacities are associated with the parcel distribution segment and serve for temporary storage and sorting of shipments. In most cases, the facilities are owned by companies rather than being leased, while the warehouse area depends on the scope of business of individual entities. The surveyed warehouse area ranges from 2,500 m² to 30,000 m².

Almost all large warehouses (around 5,000 m²) are located in the area of the Zagreb transportation hub (Zagreb and its surroundings), while in larger cities (Rijeka, Osijek and Split), there are mostly cross-dock terminals for consolidating freight flows or smaller warehouses, with an area of up to 3,000 m². Split is somewhat of an exception because numerous warehouses are located in the Dugopolje area (Split hinterland).

The average warehouse occupancy is around 80%, except for companies that have invested in building new facilities in the last two years to meet future demand. The majority of service providers (88% of respondents) expected an increase in demand for logistics services in the next few years, which has mostly materialized. Given the high occupancy rates of warehouse capacities from 2020 to the present, new warehouses are being built or existing ones expanded, primarily in the area of the Zagreb transportation hub.

In the market of warehouse capacities, there is a shortage of distribution warehouses with modern equipment and design, as well as specialized warehouses.

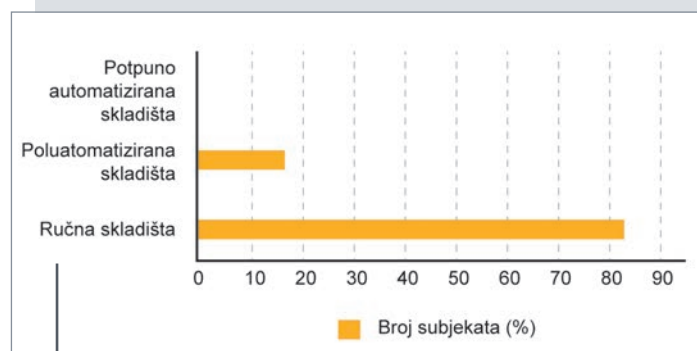
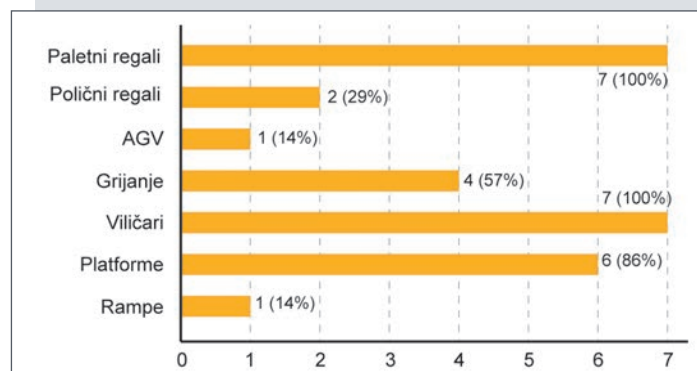


Figure 5: Frequency of use of warehouse equipment and level of warehouse automation in Croatia in 2019
Source: [10]

The application of automated warehouse systems in Croatia is limited. Figure 5 shows the frequency of using warehouse equipment and the level of warehouse automation. Although this varies depending on the type of goods and business activities, research findings have shown that standard warehouse equipment (pallet racks, forklifts, ramps) is mostly used everywhere, while the level of automation, regardless of the technology, is low. Distribution warehouses of the surveyed entities were generally not equipped with medium or highly-automated warehouse systems. The share of specialized warehouse equipment (warehouses with narrow aisles, drive-in racks, FIFO racks, double-depth racks) was also low; less than 10% of warehouses have this type of equipment. In the parcel distribution segment, sorting centers of certain operators are equipped with automated package sorting systems [10].

In the period after 2021, there have been noticeable shifts in the introduction of automated warehouse systems in the market of the Republic of Croatia. The reasons for this include the increasing shortage of labor (besides the lack of workers, high employee turnover reduces efficiency), the potential expansion of the gravitational zone after entering the Schengen regime of goods control, the need for better utilization of available warehouse space and the construction of new storage capacities. The technologies considered most frequently depend

on each subject. There is a tendency to introduce more advanced forms of automated systems (such as AutoStore, AS/RS systems with integrated picking (Shuttle systems) or vertical modules) in combination with manual processes. In parallel, there are several so-called integrator-subjects in the market offering technological and technical solutions for automated systems.

In conclusion, the level of implementation of automated warehouse systems in Croatia is relatively low. Considering the required size and market demands for this level of warehouse equipment, this level can still be considered appropriate. Given the level of available workforce, financial stability and the dynamics of warehouse processes, there is currently no pronounced need for the introduction of automated picking and storage systems, the implementation of which is technically demanding and requires initial investments that can only pay off with sufficient turnover over time [10]. Trends in neighboring markets, primarily Italy and Austria, where the introduction of automated systems is much more widespread, do indicate the need for broader implementation of automated systems to maintain competitiveness and expand business volume.

Leading logistics service providers in Croatia are monitoring market trends related to the development and improvement of warehouse equipment. However, the introduction of advanced storage systems or innovations in existing working methods significantly depends on the assessments of each service provider and is often limited due to a lack of resources [10].

4. Trends in the development of automated warehouse systems

The development of technology and tools related to automated warehouse systems is highly intensive in today's times. Considering the type of technology, two key development directions can be identified: computer tools for managing warehouse systems, which include various versions of Warehouse Management Systems (WMS) or Warehouse Execution Systems (WES) and technical solutions that enable efficient handling of transfer units in the warehouse.

The circumstances that drive the development and implementation of automated systems include the establishment of global supply chains, the organization of which requires electronic data interchange systems and coordination of activities within the chain. Additionally, there is an increase in product placement through multichannel distribution systems, a need for the distribution of larger volumes of goods, a reduction in delivery times to end-users and continuous growth in e-commerce. [11]

Accordingly, a significant increase in investments in automated warehouse systems and equipment is expected in the next medium-term period, as evident in Figure 6..

The level of adoption of automated warehouse systems varies in each market. Currently, the USA, Germany and China have a 50% share in the automated warehouse systems market. In the future, the USA is expected to maintain the largest market share, followed by EU countries with an expected share of around 30%. There is also anticipated significant market growth in developing countries, primarily in Southeast Asia and the Middle East.

One of the main drivers of warehouse automation is e-commerce. Technologically, the reason for this lies in the structure of customer orders, where there is a prevalence of a large number of orders with a small number of items and individual packaging of products. The consequence of such order structures is the need for a large number of operators, with relatively low efficiency per operator and a low level of storage density in picking zones. Automation of processes in such cases brings significant improvements in productivity (more than 30%), space utilization and reduces dependence on workforce fluctuations. Additionally, the expected level of accuracy in order fulfillment is higher compared to traditional systems.

Trends in the implementation of various automated solutions indicate that there is increasing adoption of different forms of autonomous vehicles (AGVs, autonomous forklifts), as well as autonomous mobile robots (AMRs), collaborative robots (Cobots)

Global Market of Automated Warehouse Systems - Current State and Forecast (2016–2027)

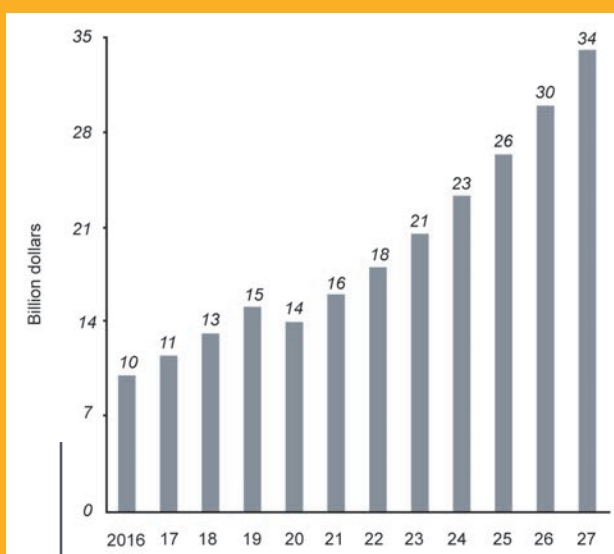


Figure 6: Expected investments in automated warehouse systems until 2027
Source: [11]

and automated storage and retrieval systems (AS/RS, AutoStore and related technologies, VLM technologies).

At the process level, a broader application of Warehouse Execution Systems (WES), cloud-based data exchange systems (cloud computing) and Business Process Management tools (ERP) with built-in modules for managing warehouse systems and processes is expected

5. Conclusion

Automated warehouse systems are increasingly being applied in modern warehouses. The reason for this is the development of technical and technological prerequisites that enable the application of an increasing number of technologies and control systems in warehouses.

Automated warehouse systems are not applied on a massive scale, which is associated with high implementation costs and the expected return on investment period. The current level of implementation costs justifies the introduction of fully automated systems in warehouses with a high level of daily throughput (such as large distribution centers with more than 2,000 orders per day), while partial automation is possible in smaller warehouse facilities.

Today, a wide range of automated warehouse systems with different levels of automation is available on the market. This allows for the design of technological solutions for warehouse systems that are tailored to the needs of users and the expected level of investment to the greatest extent possible.

The most important reasons for implementing automated warehouse systems are the shortage of personnel, the need for better utilization of warehouse space, increased efficiency and higher order fulfillment accuracy. Distribution systems also influence the choice of technological solutions in warehouses. Multi-channel distribution systems and e-commerce, with their order structure and volume, drive the transition to automated systems to maintain competitiveness and performance levels. In the future, an expected increase in sales volume in the e-commerce system will also impact the need for more intensive warehouse automation.

The most important trends in the development and application of automated warehouse system technologies are associated with the increasingly widespread use of mobile robot systems, advanced computer systems for warehouse process management, the application of advanced simulation systems in the process of improving warehouse processes and various solutions that can enhance the

overall system performance (RFID coding, the use of AR and VR systems, etc.).

The level of adoption of automated systems in warehouses varies depending on the market. The most developed markets in this regard are the markets of the United States, China and Germany, which account for approximately 50% of the total market for automated systems. Another significant market is the market of EU countries.

In the next medium-term period, an increase in the level of adoption of automated systems is expected, primarily in the markets of the United States, Germany and China, as well as in EU countries. Additionally, further advancements in technology and systems are anticipated, making warehousing operations more efficient and advanced compared to current systems.

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02

INTERVIEW WITH DAVOR PRANIĆ,
EXECUTIVE MANAGER OF "SKLADIŠNA LOGISTIKA", LTD.

AUTOMATION OF LOGISTICS SYSTEMS - Experiences from the Industry

We spoke with Davor Pranić, the Executive Manager of the company "Skladišna logistika" Ltd., the general representative of Toyota Material Handling Europe (TMHE) and Kalmar for Croatia, about the complexity and level of automation in Croatia's warehouse systems



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Could you evaluate the current and expected state of the market for advanced logistic solutions in Croatia and neighboring countries?

The market situation analysis should be divided into two segments: the clients' readiness for investment and the supply from providers.

Based on our three-year experience offering advanced solutions, we can conclude that our analysis of clients is limited. However, the Croatian logistics market has shown that clients connected to manufacturing, with a high demand for product delivery speed, are interested in automating logistics processes. In the production of food products, there are simple, repetitive actions of handling goods from the production line to the warehouse that can easily be automated by autonomous vehicles. This is a simpler form of using technology that justifies the investment by reducing the need for human resources.

Providers of advanced solutions are mostly companies outside Croatia that choose projects based on the size and type of technology being implemented. This is the primary reason why very few automated logistic solutions have been implemented in the Adriatic region. In conclusion, client demands for such solutions will grow and contribute to the development of integrative services that we also strive for.

To your knowledge, what are the most significant trends in the development of automated solutions in warehouse systems?

The buying culture has changed as customers order products online at the best price with rapid delivery times. This demand is altering logistics settings and requires technology to achieve this. In today's logistics processes, efficiency in picking one product for home delivery is crucial. Over 80% of goods leaving the warehouse are a single product or box that needs to be manually taken from the shelf. In most cases, a worker travels with a forklift or trolley to retrieve these products. This concept is called "person to goods". Technology that enables the "goods to person" concept enhances efficiency in warehouse processes and is among the most significant trends in developing automated solutions.

Could you specify in more detail the activity of the Toyota Material Handling department?

As a representative of Toyota Material Handling Europe, Warehouse Logistics provides expertise to clients in handling goods. From the moment a product is ordered until its delivery to the final address, there are many steps involving handling that product. Our goal is to advise clients to find solutions for their logistical processes and thus deliver the requested

product as quickly as possible at the lowest costs.

Toyota Material Handling Europe has a very wide product portfolio offered in the market, making it challenging to rank them in terms of importance, but we are recognized for the quality of forklifts produced in European factories. Alongside technology sales, Warehouse Logistics ensures maintenance services through its service network.

In addition to the basic program, TMH also offers various solutions for automated warehouse systems tailored to different warehouse unit formats. In this category, solutions for designing and implementing, for instance, the AutoStore system, palletized goods handling systems, and sorting systems in batch distribution, are offered.

Within Warehouse Logistics, the Advanced Logistics department was established a few years ago. What are the most important goals and reasons for establishing this department, and what do such business models mean for the Croatian logistics market?

We identified several important challenges faced by our clients, which motivated us to launch a new department that could offer advanced logistic solutions. I would mention some of these challenges that are relevant in our market:

- Lack of workforce in logistics
- Space constraints
- Poor space utilization
- Lack of knowledge about process improvement in logistics
- Incorrectly delivered products.

During the COVID-19 pandemic, which further fueled online shopping culture, these aforementioned challenges were even more strongly felt. Customer satisfaction was linked to product availability, price and delivery speed, and many lost trust due to poorly designed logistic processes. In the advanced logistics department, our goal is to improve the quality of our clients' businesses based on analyzing their processes and data, aiming to offer technology that best suits them through an agnostic approach. Often, with such advisory approaches, the solution can be a differently structured process or an inventory approach, and by improving these two segments, clients enhance their work efficiency. However, for better space utilization, organization and reduced dependency on labor, implementing advanced technology that automates actions in logistics is necessary. Integrating automated technology requires extensive knowledge gained through employee education. The primary goal of Warehouse Logistics is to become an independent integrator by enhancing the competencies of our team in collaboration with partners. One of the important partners on this

journey is the Faculty of Transport and Traffic Sciences, Department of Transport Logistics, with whom we closely collaborate in analyzing processes and data and simulating solutions using the Flexsim software.

What are examples of advanced technological solutions in the TMH system that, in your opinion, have the potential for broader application in the markets of Croatia and neighboring countries?

In our system, Toyota's autonomous forklifts and vehicles are highly efficient solutions for automating goods transport in warehouses and placing them in shelving locations. With advanced lithium battery technology, such forklifts can operate in three shifts. The software T ONE manages the forklifts' connection to warehouse management systems (WMS), offering the user many vehicle management options. Additionally, I would highlight very good technological solutions from companies like Vanderlande (Adapto) and AutoStore.

Adapto is designed based on today's online shopping. It ensures the flow of high volumes of goods in the right sequence and at the right time. Adapto integrates storage, picking, inter-warehouse movement based on the order of goods and orders, with very high precision.

AutoStore is a company with which TMH collaborates as a global integrator, offering a product that maximizes warehouse space up to a height of 10 meters, focusing on picking products or boxes.

One of the major hindrances is finances for implementing such advanced systems. Are there any incentives for companies opting for implementing advanced logistic solutions, and do you see potential in that area for market development and attracting potential new users?

For every logistic process automation project, in our case, we conduct a profitability analysis. It indicates the financial return on investment, which is the most critical factor in the decision. Additional benefits are less measurable but significantly enhance business operations. Maximum space utilization, process efficiency and reduced dependency on labor are fundamental advantages that I would emphasize.

For clients, the possibility of financing equipment procurement and implementation is crucial, as these are long-term and financially demanding investments. In this regard, it is extremely important to generate interest among financial institutions to initiate financing lines that would facilitate the implementation process of advanced logistic solutions in distribution and industry, significantly improving logistical processes and market competitiveness. ●

03

INTERVIEW WITH ŠIMO MARIĆE,
MANAGING DIRECTOR OF "CHROMOS – SVJETLOST" LTD.

CHROMOS-SVJETLOST in Traffic Applications

The quality and manner of marking infrastructure significantly influence road traffic safety, which is a priority for global organizations and a focus of state policies. In order to emphasize the importance of this issue, we spoke with Šimom Marićem, managing director of CHROMOS – SVJETLOST d.o.o.



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Can you explain the connection between CHROMOS-SVJETLOST company and the importance of using products to enhance traffic safety?

CHROMOS-SVJETLOST d.o.o., a paint and coatings factory, has been actively developing solutions for over 100 years in the protection and decoration of construction materials (wood, metal, concrete, asphalt) for both industrial and general consumer applications. The company places significant focus on traffic-related systems, including horizontal signaling, tunnel lining protection and protection for guardrails, overpass fences, bridges, noise barriers and windbreak supports. The emphasis is also on using the highest quality materials that have a substantial impact on traffic safety.

Concerning marking and horizontal signaling, can you specify the methods of application and highlight how high-quality execution can increase driving safety?

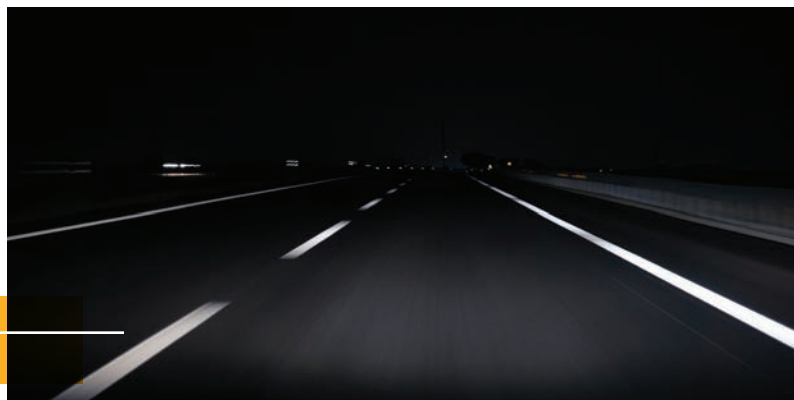
Proizvodi tvrtke koji se primjenjuju u cestovnoj horizontalThe company's products applied in road horizontal signaling have proven their efficacy over decades in projects involving national, regional and municipal

roads, as well as numerous road signaling contractors. Maintaining driving safety is achieved through quality execution and regular maintenance of horizontal signaling, utilizing two different technologies in our case: EKOSIGNOL road paint and EKOSIGNOL PLASTIC 2K two-component cold plastic.

Horizontal signaling is a system involving color and reflective beads, with key features for driving safety including daytime visibility (whiteness/contrast), nighttime visibility (retroreflection), visibility in wet conditions/rain and skid resistance.

Regarding color, the company produces EKOSIGNOL, paint for thin-layer horizontal signaling. It is a homogeneous, air-drying acrylic coating with fast drying, good elasticity, coverage, excellent adhesion to any road surface and resistance to wear

Examples of horizontal signaling with different quality of nighttime visibility





Example of the color being used on the A5 motorway section, "Slavonika"

caused by traffic. It is available in white and yellow shades, and a wide range of shades can be obtained using a machine tinting system.

Depending on climatic conditions, Ekosignol road paint is applied in both types of horizontal signaling:

TYPE 1 – Wet film thickness of 400 μm (bead consumption 400 g/m^2 , paint yield 1–1.5 m^2/l)

- Retroreflective beads from 100 to 850 μm
- Good daytime and nighttime visibility on dry surfaces
- Reduced nighttime visibility in wet conditions/rain

TYPE 2 – Wet film thickness of 600 μm (bead consumption 480 g/m^2 , paint yield 0.8–1 m^2/l)

- Retroreflective beads from 200 to 1,400 μm
- Good daytime and nighttime visibility on dry surfaces
- Good nighttime visibility in wet conditions/rain

When it comes to two-component cold plastic, it is extensively used. Can you comment on its specificity and impact on traffic safety?

Two-component cold plastic has significant advantages, adhering well to concrete or asphalt and existing solvent-based paints and cold plastic markings, provided the previous markings had good

adhesion to the surface. It is highly resistant to wear, has good resistance to motor oils and fuels, and is weather-resistant. It can be applied manually, with semi-automatic ("walk-behind" equipment) or automatic devices.

In practice, how does the application of two-component cold plastic marking work?

Road markings (arrows, signs, letters and numbers) are drawn on a prepared surface using chalk and templates. Afterward, the templates are removed, and protective masking tape is applied around the chalk-drawn edges. Then, within the marked area, the product is applied using a trowel to achieve the desired film thickness. The protective masking tape must be removed before the product hardens (after 5–8 minutes). Reflective beads are then applied.

"Draw boxes" (metal frames with an opening for material exit) can be used in low-traffic areas and for stop lines. The width of the metal frame determines the line width, while the opening through which the material exits determines the thickness of the application.

Before application, the product is mixed with a hardener, either in an open (about 1 minute) or closed mixing system. In manual application, a powdered hardener is used, while liquid and powdered hardeners can be used when working with a machine, depending on the equipment. The recommended weight ratio of hardener is 1–2%, depending on the substrate temperature.

Although the product already contains a certain amount of premix beads for better nighttime visibility, additional glass beads are applied by sprinkling on wet paint – 5 seconds after paint application. The bead consumption is 450 g/m^2 .

In addition to long-lasting traditional signaling, EKOSIGNOL PLASTIC 2K is most commonly used to



Enlarged example of Ekosignol TYPE 1

Enlarged example of Ekosignol TYPE 2





• *Marking external asphalt surfaces in a distribution center*

create vibro or warning stripes on the road (full stripes in tunnels, stopping stripes on highways, etc.) and for marking pedestrian crossings in high-traffic urban areas.

The paint is recommended to be diluted up to 5% if necessary. After achieving the specified wet layer thickness, glass retroreflective beads for nighttime visibility are sprinkled on the paint – 5 seconds after paint application.

For these examples, as with all influential manufacturers, Ekosignol road paint and EKOSIGNOL PLASTIC 2K cold plastic have multiple certificates in the reflective bead system from various manufacturers, ensuring durability on the road, low skid resistance and high values of daytime, nighttime and wet visibility.

Manufacturers align their compliance with horizontal signaling systems with predefined standards, including HRN EN 1423 Materials for road markings - Glass beads, aggregates for skid resistance reduction and their mixtures, HRN EN 1436 Materials for road markings - Characteristics necessary for road users and HRN EN 13197 Materials for road markings - Wear simulators. The systems are tested by authorized institutions within the European Union. After testing, authorized institutions issue durability testing certificates for the tested system.

Although the conversation focuses on road traffic safety, these mentioned products are also used for marking areas on asphalt and concrete surfaces in both indoor and outdoor conditions, such as garages and logistics facilities.

In addition to horizontal signaling, tunnel lining protection is crucial for traffic safety. How are the established standards satisfied?

Indeed, the company has been involved in a series of projects related to tunnel lining protection. A

• *Markings on the underground garage of Puskás Aréna football stadium in Budapest*



standout in the production lineup of CHROMOS-SVJETLOST d.o.o. from Lužani is the KEMEPOX AQUA system for the surface protection of internal concrete linings in tunnels, aligned with high standards.

Technically, the system is epoxy-based, water-dilutable and comprises two types of two-component coatings: KEMEPOX AQUA impregnation as a primer or impregnation and KEMEPOX AQUA as the final protective coating, available in various requested shades depending on needs. The system prevents the penetration of harmful substances and water and is resistant to temperature variations.

The requirements for tunnel lining coatings relate to the overarching product standard for the protection and repair of concrete structures, EN 1504, which has been fully applicable since 2009. Existing national standards align with the new EN 1504, making the CE marking mandatory. Specifically, the standard HRN EN 1504-2 Surface protection systems, which applies to tunnel linings, prescribes minimum requirements, necessary assessment and diagnostic procedures, as well as quality control of materials and works.

How are such demanding projects operationally carried out?

Operationally, the technology for rehabilitation painting begins with the placement of temporary traffic signaling, all in coordination with the project manager, depending on the possibility of carrying out works with traffic or the option of closing the tunnel tube. After setting up traffic signaling and shutting down ventilation (allowing minimal ventilation and a reduced number of fans to operate), workers enter the tunnel tube with equipment and vehicles from the contractor.

The first step in the tunnel lining painting process is inspecting the inner surface of the tube and determining its condition, which can also be demanding.

The substrate must be solid, dry, clean, degreased, free of dust, oil and other impurities, with moisture content not exceeding 3.5%. Weakly adhered parts of the substrate and old coatings must be removed. Any irregularities, depending on their depth, need to be filled with suitable remedial mortars or leveled with leveling compounds.

After washing a specific section of the tunnel lining, protective film is applied to cameras, signaling, markings for distance from exits and tunnel entrances. A designated number of workers, depending on the length of the tunnel tube, are responsible for protection. They will protect the necessary parts ahead of painters and remove protection after coating application before the end of the shift and full traffic release in both directions.

Impregnation coating and the final layer of coating are applied to the prepared tunnel lining, which is prepared by washing with available technical material means (vehicle, tanker with a sufficient water tank, connection with a brush for cleaning the lining, high-pressure washer with hot water, cleaning and degreasing agent).

The surface is dry to the touch after 4 hours and completely dry after 8 hours. The inter-coat interval is 24 hours, the surface can be mechanically loaded after 4 days, and it is fully cured after 7 days (under room temperature conditions). Higher temperatures

shorten, while lower temperatures extend the working time.

Both coatings, Kemepox aqua and Kemepox aqua impregnation, are applied with a brush, roller (textured polyamide roller with a hair height of 11 mm) or Airless spraying device (without a filter, minimum pressure of 50 bars, nozzle size 0.015–0.017 inches, spraying angle of 45°), usually with subsequent roller treatment and/or occasional activation of ventilation units in the tube. It is recommended to apply coatings under optimal working conditions because higher temperatures shorten and lower temperatures extend the usability time. The substrate temperature should always be at least 3°C above the dew point temperature. The waiting time between two applications should be at least 16 hours and a maximum of 48 hours (depending on weather conditions).

The image shows work in the Brinje tunnel, the red line is executed on the side of the tunnel, featuring evacuation passages, with a width of 50 cm (RAL 2002). The evacuation line on the tunnel lining is performed with the lower edge of the line at a height of 90 cm from the pedestrian walkway level. It is recommended to apply red epoxy paint with rollers for the final aesthetic appearance of the evacuation line and protection of the environment from splashing. The red two-component epoxy paint for the evacuation line is applied to the prepared and painted tunnel lining.

Mravince tunnel, works performed in 2019





Work in the Brinje tunnel, 2019

Emergency exits must be marked with the prescribed sign and entrance areas must be painted with green color (usually RAL 6024) using the Kemepox aqua system, to which a photoluminescent pedestrian symbol facing the entrance is applied.

Coatings are always applied according to the manufacturer's instructions (ambient temperature, humidity, time between layers, preparation of coatings, etc.).

Have you worked on the protection of a large number of tunnels in Croatia?

Some of the tunnels in Croatia with linings protected by our systems include Ledenik, Mravnice on the state road DC1, the Solin-Klis section, Veliki Gložac, Brinje, Vranduk, Ormanica, Podvugleš, Javorova kosa, Plasina, Čaklovići, Kamenice, Debeli Brijeg, Lučice, St. Mark's tunnel, etc.

Is the protection of guardrails, bridge railings, overpasses, windbreak supports, noise barriers and other steel/galvanized elements along roads also relevant and influencing safety?

Indeed, protection systems for both steel and galvanized elements fall under the unified standard HRN EN ISO 12944, which prescribes everything related to corrosion protection, from surface preparation to operating conditions. The system also defines the corrosive conditions in which the elements are located (corrosion classes), the expected durability of individual systems and certification requirements (compliance testing of the system under simulated conditions).

Metallic elements used to enhance road traffic safety, whether they are guardrails, noise barriers, windbreak supports or railings on various bridges, are usually galvanized. Galvanizing extends the

material's lifespan and the surface is somewhat more demanding for coatings, so quality preparation before painting is crucial.

According to the standard HRN EN ISO 12944-4, hot-dip galvanized coatings on iron and steel items are prepared in various ways depending on the quality of galvanizing and the surface condition due to exposure to weather conditions.

Surface defects and damage to galvanization must be repaired to achieve the protective properties of zinc coatings. All impurities from the surface, such as dust, weakly adhered particles, oil, grease, soldering or marking agents, etc. need to be removed by sandblasting.

The purpose of sandblasting is to quickly or lightly pass non-metallic abrasive over the surface of metal coatings to clean or roughen the surface without removing it from the substrate, aiming to improve adhesion between the metal coating and the coating system applied to it.

The interested parties agree on the required cleanliness and roughness of the surface and the minimum thickness of the zinc coating. For this purpose, a test surface can be prepared, where different parameters such as the hardness and particle size of the abrasive, the angle of the nozzle, the distance of the nozzle from the surface, air pressure on the nozzle, etc. can be optimized. Sandblasting usually uses low air pressure and sharper abrasive (grit) of finer granularity.

After sandblasting, the galvanized coating must remain uniform, undamaged and uninterrupted, without shine and without impurities that could reduce the durability of the zinc coating and the coating system applied to it.

If the hot-dip galvanized surface has been exposed to weather conditions, there is a possibility that zinc corrosion products (white rust) and other impurities have accumulated. Such surfaces need to be cleaned by an appropriate cleaning method depending on the type and extent of contamination. Oxidation products, certain salts and other impurities can be removed by washing with clean, fresh water and detergent or using synthetic fiber cloths with built-in abrasive, followed by thorough rinsing with hot water.

For the mentioned process, it is extremely important to focus on the quality selection of corrosion protection systems?

Indeed, the corrosion class and durability are defined by the client and vary from C3 for guardrails in a continental climate to C5 for windbreak support pillars of bridges in a marine atmosphere, with the

most common being high to very high expected durability (15–25 years or >25 years).

In our example, CHROMOS-SVJETLOST d.o.o. offers systems in its production lineup that are confirmed for all corrosion class conditions from C2 to C5 in all expected durability conditions, whether it is steel or galvanized elements.

How is the preparation and processing of materials carried out and how demanding is it?

In our company, the base coat KEMEPOX GO is a two-component epoxy coating with a high content of anti-corrosive pigments, excellent adhesion to all types of painted metals and steel, and outstanding mechanical and chemical resistance.

After the drying of the base coat, the final coat, for example, KEMOLUX PUR DS, is applied in the desired shade. This is a two-component protective polyurethane coating with high resistance to atmospheric influences, excellent UV protection, high elasticity, as well as chemical and mechanical resistance.

It is necessary to pay attention to the ratio of mixing components, induction time and working time of the mixture. Coatings are applied manually (brush/roller) or by airless and air spraying on a dry surface.

In the case of renovation projects (on construction sites), railings are mostly protected by manual application, while in the case of new constructions (in workshops), they are manually "touched up" (brushes and rollers are used to coat all joints, welds and hard-to-reach areas). Afterward, they are sprayed with airless devices. During the application, it is necessary to adjust the pressure, angle and size of the nozzle, dilute the coating if necessary, and consider environmental temperature, surface temperature and dew point temperature.

Example of a pedestrian bridge railing with a protective system for C3, >25 g



Although operationally demanding, a significant number of pedestrian bridge railings, overpasses and noise barriers have been protected using this system in Croatia and beyond.

Are three-layer systems significantly involved in projects?

Three-layer systems are sought in exceptional situations when zinc-coated elements are additionally exposed to a marine or chemically aggressive environment. In such cases, the most commonly offered protection system is a system with a total dry film thickness of 320 µm.

The durability of protection is further extended by increasing the volume of the protective coating barrier with thick-layer coatings, such as KEMEPOX MASTIC JO coating, a two-component epoxy coating of exceptional mechanical and chemical resistance. Its purpose is to prevent the penetration of water to the surface of metals.

This system has been used in the protection of guardrails and windbreak support structures for the Pelješac and Krk bridges, as well as access roads.



Example of a crash barrier and wind protection support on the Pelješac Bridge

Do you use your systems to enhance the safety of other forms of transportation?

Certainly, CHROMOS-SVJETLOST d.o.o. is involved not only in road safety but also in the safety of railway transport. In the last decade, most railway bridges have been renovated using either the two-component KEMEPOX/KEMOLUX PUR DS system or the single-component HARDLUX DS protection system. ●

04

ZIRP 2023

International Conference ZIRP - The Science and Development of Transport

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The ZIRP Conference once again brought together distinguished experts from Europe and around the world with the aim of presenting innovative solutions based on scientific research and their practical applications in the field of transportation and logistics.

Organized by the Faculty of Transport and Traffic Sciences, this year's ZIRP Conference – The Science and Development of Transport was held from 7 to 8 December 2023, in Zagreb, under the patronage of the President of the Republic of Croatia, the Ministry of Science and Education, the Ministry of Tourism and Sports, and the University of Zagreb.

The sponsors of this year's Conference were: the Croatian Vehicle Center, Gamax Laboratory Solutions, the Croatian Chamber of Economy (HGK), Orbico and Quehenberger Logistics. The Conference partners included: Arriva Croatia, cargo-partner, Croatia Airlines, Croatian Post, Ericsson Nikola Tesla, EIT Urban Mobility RIS Hub Croatia and the University of Zagreb.

The ZIRP Conference once again brought together distinguished experts from Europe and the world with the aim of presenting innovative solutions based on scientific research and their practical applications. Various topics were discussed, primarily related to the possibilities of recovering the operation of supply chains after difficulties caused by global crises and threats.

The speakers presented their insights, knowledge, and research, all aimed at advancing scientific expertise and observations and enhancing possibilities in the fields of transportation, logistics, and aeronautics.

Lectures at the ZIRP 2023 Conference





• Panel Discussion "Resilient Transport Systems and Logistics"

Invited speakers delivered the following lectures:

- **Justyna Świeboda, Ph.D.** – Polish Road Transport Institute, "Uncertain Freight Conditions in the Europe Road Transport Market in Times of Crisis"
- **Marko Kapetanović, Ph.D.** – Delft University of Technology (TU Delft), "Decarbonizing Regional Rail Transport: Shifting to Alternative Propulsion Systems and Energy Carriers"
- **Andre Luiz Cunha, Ph.D.** – University of São Paulo (USP), São Carlos School of Engineering (EESC) "The Use of Deep Learning and Open Data in Some Transport Problems"
- **Marco Rossi, Ph.D.** – MathWorks Academia Team, "Latest Trends in Automotive and Transport Industry: From AI to Virtual Worlds"
- **Dirk Sackmann, Ph.D.** – Julius Maximilians University of Würzburg, "Challenges in Agricultural Supply Chain Management"

On the first day of the Conference, a panel discussion titled "Resilient Transport Systems and Logistics" was held, where experts in the field of transportation and logistics discussed sustainable urban mobility,

logistics and improving competitiveness in the market of transportation and logistics services. The panel featured the following speakers:

- **Petar Šimić** – Croatian Chamber of Economy (HGK);
- **Bence Huba** – EIT Urban Mobility;
- **Luka Novačko** – Faculty of Transport and Traffic Sciences.

Additionally, on the first day of the Conference, the **ZIRP Youth** event dedicated to students was organized. A panel discussion titled "Skills for Future Business Environment" was held, focusing on the necessary knowledge and skills required to meet the needs of the growing business environment. Foreign students participated in a combined intensive program called "Resilient Transport Systems and Logistics" within the Erasmus+ program, approved by the University of Zagreb. Through ZIRP Youth, students presented their research, projects and ideas developed independently or in collaboration with various institutions or teams, fostering further knowledge and experience exchange.

During the two days of the Conference, the following workshops were held:

- Workshop "Urban Mobility Day";
- AeroSTREAM, Project Workshop, "Applications of UAVs in Logistics";
- PTV User Group Meeting, "Shaping the Future of Transportation and Mobility in the Region".

The project "Twin Transition Urban Mobility" organized by Urban Mobility RIS Hub Croatia was presented. Two panel discussions were held under the titles "Energy Transition in Urban Mobility" and "Where Do We Need Innovation Most?". Also presented was the international project "Green and Safety Skills for Workers in Bike-Based Urban Last-Mile Deliveries (SAFE-LMD)", aiming to educate bicycle workers on green and safety skills in urban delivery. The project was organized by BGZ-Berlin, the University of Zagreb, ECQA, ECF and EXELIA.

There were 223 registered conference participants and 54 papers were submitted. During the

conference, 41 papers were presented, which, after the review process, were accepted and will be published in the "Transportation Research Procedia" proceedings by Elsevier, indexed in Scopus and publicly accessible (open access) in the ScienceDirect database. The papers were presented based on the themes of "Transportation", "Traffic Infrastructure", "ITS and Transportation" and "Sustainable Logistics and Global Value Chains".

This year's ZIRP fully met expectations in terms of the number of participants and the relevance of topics discussed. The goal is to further enhance networking among all scientific and professional stakeholders in the fields of transportation, logistics and aeronautics, providing interested parties with added value through access to information on new technologies, knowledge, insights and ways of their implementation while maintaining an open approach to all current issues. ●

Panel Discussion "Skills for Future Business Environment", ZIRP Youth



05

CikloParking – Project for the Development of the National Database of Bicycle Parking Supply and Demand



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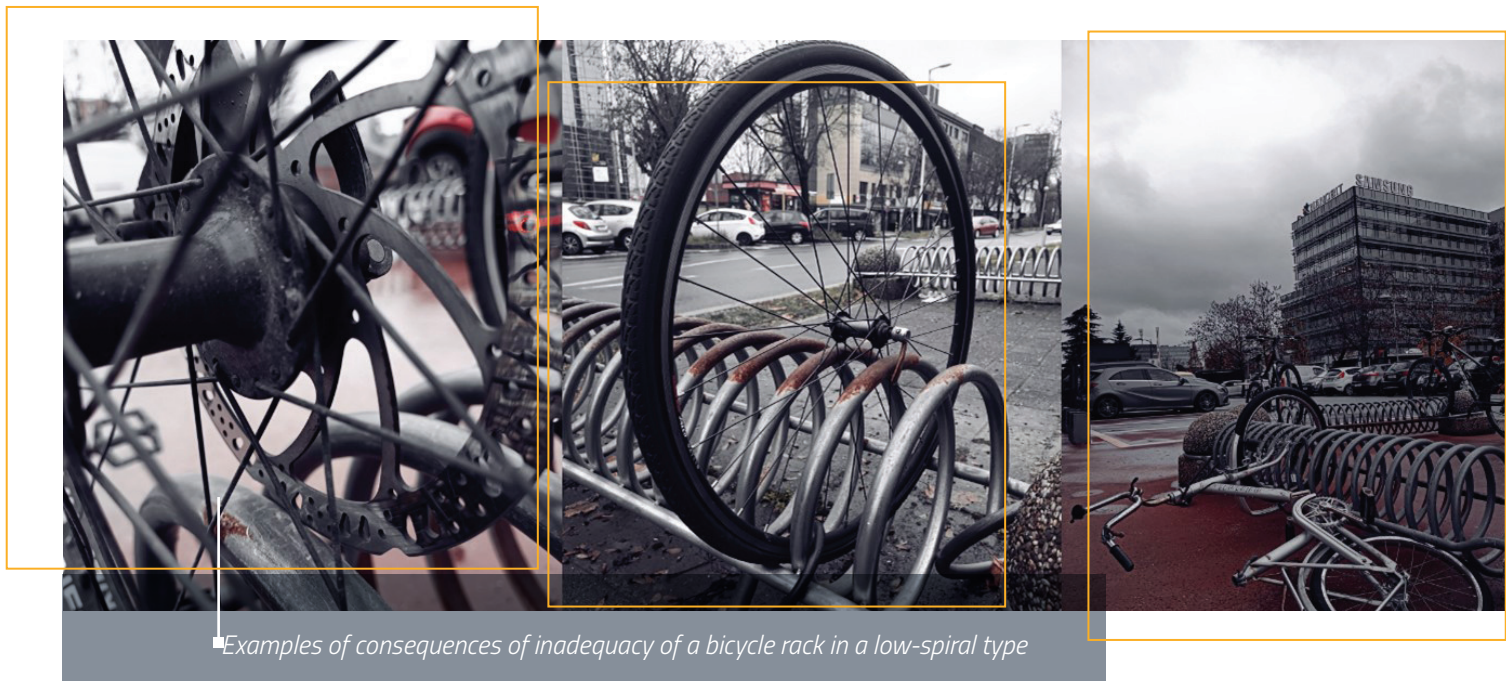
Through the professional initiative of an interdisciplinary team from the company ACADEMICA d.o.o. for traffic planning and technology development, a publicly accessible National database of bicycle parking supply and demand has been developed. This has created the prerequisites for collective action among residents, businesses, public administration and professionals. The National database of bicycle parking supply and demand is defined as a WebGIS platform based on the integrated system "CikloParking", a web application for collecting, displaying and analyzing spatial data, primarily focusing on existing bicycle infrastructure.

Professional initiative based on the provisions of the Regulation on Bicycle Infrastructure

The [Regulation on Bicycle Infrastructure \(NN 28/2016\)](#) prescribes basic planning principles and elements for the design, construction and maintenance of bicycle infrastructure. With the aim of timely and effective achievement of the safety, economy, completeness, directness and attractiveness principles defined by the Regulation on Bicycle Infrastructure, Article 67 of the Regulation establishes deadlines for aligning existing bicycle infrastructure with the provisions of the Regulation. Although the deadlines defined by the Regulation for aligning the existing state of roads and other traffic surfaces, as well as markings and signaling on roads and bicycle surfaces, expired in March 2018 (the existing state) and March 2019 (markings and

signaling), a significant proportion of cities and municipalities in the Republic of Croatia (out of a total of 556 units of local self-government in Croatia) are not familiar with the content or provisions of the Regulation on Bicycle Infrastructure.

Considering the high level of underdevelopment of bicycle infrastructure in many units of local self-government in the Republic of Croatia, often justified by spatial limitations and a lack of budgetary funds for financing traffic studies, this directly affects the demotivation of cyclists from the perspective of positive participants in the existing traffic system. In their everyday use of bicycles as a means of transportation (a modal distribution share of 5% according to research conducted for the development of the National Traffic Model for the Republic of Croatia; Ministry of Maritime Affairs, Transport and Infrastructure; 2016), cyclists' constitutional right to mobility is restricted



Examples of consequences of inadequacy of a bicycle rack in a low-spiral type

by inadequate traffic infrastructure. Moving through inadequate or alternative infrastructure and risking their safety, cyclists often face challenges with bicycle storage or parking upon reaching their destination. The absence or inadequacy of bicycle racks in public spaces, which do not require traffic studies for implementation and are not a significant budgetary burden, is an example of neglect, lack of consideration for minimal standards of infrastructure readiness and potential disregard for cyclists (and scooter riders). In such cases, their contribution to sustainability is ignored or even penalized.

In line with the mentioned challenges and aiming to standardize at least one element of bicycle infrastructure at the national level in the Republic of Croatia, aligning it with the Regulation on Bicycle Infrastructure, the [CikloParking project](#) emphasizes parking areas and devices for bicycle parking. It is important to highlight the following provisions defined by the Regulation:

- Article 59, paragraph 2: Parking devices should be securely fixed to the ground or the structure in which they are located, enabling safe and accessible locking of the bicycle to the bicycle frame.
- Article 59, paragraph 4: It is recommended to provide at least 30% covered parking areas near public facilities.
- Article 60, paragraph 1: The minimum capacity of bicycle parking areas depends on the type of facility nearby and is determined according to the following table:
 - Business activities – 1 bike parking space per 100 m² of gross area (for employees)
 - Shopping center – 5 bike parking spaces per 100 m² of gross area (for visitors)
 - Educational institution – 2 bike parking spaces per 5 students or employees

- Recreational center/hall – 10 bike parking spaces per 100 seats (for visitors)
- Theater and cinema hall – 10 bike parking spaces per 100 seats (for visitors)
- Bus and train station – racks for 10% of daily passengers at the station
- Hospital – 10 bike parking spaces per 100 beds (for visitors)
- Student dormitories – 6 bike parking spaces per 10 users.

With the defined approach, the primary project goal is to spatially identify, assess and analyze all publicly accessible racks for bicycles and scooters in the Republic of Croatia, as well as the need for the implementation of adequate racks in locations where they are not available or the existing ones are not suitable.

Project contribution to the improvement of the profession, public administration and society

Due to the lack of secured budgetary funds, professional staff, and/or political will, managers of traffic systems (local self-government units in the Republic of Croatia) often do not continuously collect, process and analyze data on traffic infrastructure or mobility indicators. Research implementation is often conducted partially and with uneven methodology, adapting to the project tasks of individual initiatives. This approach directly impacts the performance of the transportation profession and public administration, resulting in inefficient and slow development of a sustainable transportation system, primarily bicycle infrastructure. Besides negative developmental consequences, there is a potentially negative perception among active cyclists who may feel that system managers and other stakeholders

in the existing transportation system consider them unimportant.

[With the CikloParking professional initiative](#), conditions have been created for the collaborative efforts of key stakeholders in the transportation system. The CikloParking web application system serves as a public platform for interaction among residents, public administration, institution/business managers and transportation professionals. Through active project participation, key stakeholders gather data and exchange opinions on crucial development topics in sustainable mobility, with a focus on bicycle infrastructure. All collected data are integrated into the National database of bicycle parking supply and demand, defined as an innovative WebGIS platform with accompanying tools for spatial representation, processing, analysis, reporting, printing and exporting high-quality professional indicators.

This approach enables residents to provide free and anonymous evaluations of the existing transportation infrastructure, primarily related to cycling. They can express their views and suggestions for improvement. For system managers, it facilitates more efficient enhancement of the transportation system and management of bicycle parking supply and demand

Interdisciplinary approach and innovative technologies for more effective traffic planning and management

[The CikloParking application system](#), developed through the application of knowledge in the fields of traffic planning, design, spatial planning,

geoinformatics, spatial database management, statistics and computer programming, is a unique attempt to develop a fully publicly accessible National database of specific traffic elements or indicators in the Republic of Croatia. With a defined level of complexity in project goals, the development processes required the application of high technology, employing interdisciplinary knowledge and methodology.

Respecting the principle of inclusivity, recommended in the creation of every strategic document for the development of sustainable mobility, the integration structure for data collection is defined by the following CikloParking applications and corresponding functions:

- [Web Survey for Residents](#)

Function: Identification of mobility means, opinions on elements of the existing transportation system and bicycle infrastructure, and factors motivating residents to use bicycles more frequently as a mode of transportation.

- [Web Survey for Local Government Representatives](#)

Function: Identification of implementation and development challenges faced by local government representatives.

- [Web Application for Reporting Bicycle Parking Supply and Demand – Residents](#)

Function: Identification of the location, type, capacity and adequacy of available racks for bicycle/scooter storage; identification of location, purpose, duration and frequency of the need for bicycle/scooter “parking” on sites with available or unavailable rack supply.



The interactive interfaces of the National database of bicycle parking supply and demand

- [Web Application for Reporting Bicycle Parking Supply – Local Government Representatives](#)

Function: Identification of the location, type, capacity and adequacy of available racks for bicycle/scooter storage in public areas of the local government.

- [Web Application for Reporting Bicycle Parking Supply – Managers/Owners of Institutions and Businesses](#)

Function: Identification of the location, type, capacity and adequacy of available racks for bicycle/scooter storage owned or designated by institutions or businesses.

- [WebGIS Platform for Managing Bicycle Parking Supply and Demand – National Database of Bicycle Parking Supply and Demand](#)

Function: Cartographic overview of identified (reported) bicycle parking supply and demand, dynamic report generation, evaluation of identified indicators, statistical overview of residents' opinions and system managers' implementation challenges, education, compliance verification with the Regulation on Bicycle Infrastructure and printing and exporting capabilities.

Project objectives and business model for the sustainability of the professional initiative in developing the National database of bicycle parking supply and demand

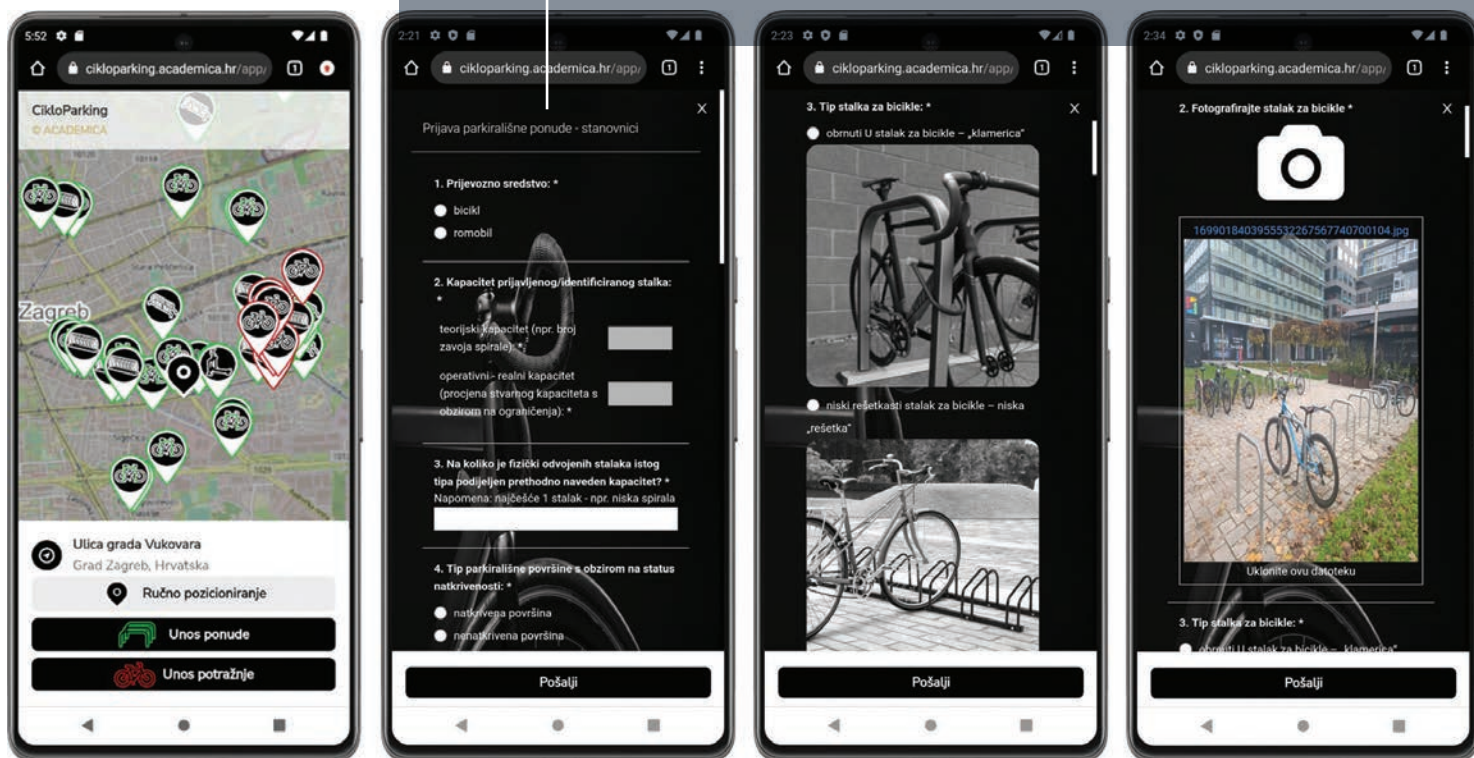
Although the CikloParking professional initiative

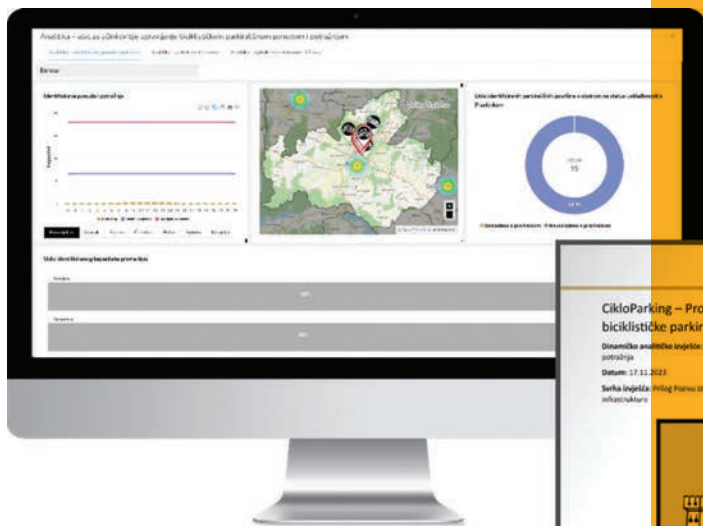
was launched on 9 November 2022, primarily based on the provisions of the [Regulation on Bicycle Infrastructure](#), with a quality development approach and broad coverage, it aligns with the [National Plan for the Development of Bicycle Traffic for the period from 2023 to 2027](#) and the [European Declaration on Cycling](#) (European Commission), as well as with strategic documents adopted during 2023. With this approach, the potential for using the data collected by the project is generated for potential applications by cities and municipalities with a representative sample for upcoming public calls for co-financing the improvement of bicycle infrastructure.

It is important to emphasize that all CikloParking web applications for collecting spatial data on bicycle infrastructure in the Republic of Croatia are free. Web surveys and applications for residents are used anonymously, and the entry of data on parking offers by representatives of institutions, businesses and local self-government units is authorized. This approach is a prerequisite for completing surveys for representatives of local self-government units, and, for this purpose, user accounts and passwords are created for stakeholders, ensuring the representativeness of the entered data.

The data collected by the project and the nationally defined indicators are publicly available in the [National database of bicycle parking supply and demand](#). At the national level, the collected data in the analytical interface are structured into the

CikloParking web application for reporting bicycle parking supply and demand





Example of a report with over a hundred professional indicators at the local level, automatically generated from the analytical interface of the CikloParking National database of bicycle parking supply and demand



following interactive tabs: analytics – identified supply and demand, analytics – survey for residents and analytics – survey for representatives of local self-government units. The provision of expertise, project development and continuous motivation of stakeholders for participation are fully financed by ACADEMICA d.o.o. The business model of project sustainability is based on the potential provision of one-time symbolic financial support from local self-government units, in accordance with the [General Terms of Use](#) of licenses for software solutions of the National database of bicycle parking supply and demand – CikloParking.

In this context, financial support covers the continuous storage of collected data, technical maintenance, verification and approval of collected data, as well as professional support and education during the implementation period. To ensure that all local self-government units, as the fundamental project goal, can utilize all the data, innovative tools and potentials, the financial support categories are defined in accordance with the population of the local self-government unit.

Through the provided project support, representatives of cities and municipalities create personalized accounts, granting them access to a detailed display of all spatial data collected by the project within the area of the local self-government unit they manage. This includes analytical tools, tools for printing and exporting spatial and alphanumeric data, as well as

tools for generating reports for potential applications for co-financing bicycle infrastructure through public calls.

CikloParking project – the reform we are implementing together

With the mentioned professional and interdisciplinary approach, based on scientific research, an interactive National database has been developed, unique in Europe. The key results from the initially collected sample confirm the project's importance and serve as motivation for all stakeholders to actively participate, engage in professional discussions and potentially contribute to further development.

“81.6% of currently identified bicycle parking areas in the Republic of Croatia, as per the project, are not in compliance with the Regulations on Bicycle Infrastructure” (n = 370 identified parking areas)

“88.2% of cities and municipalities that filled out the “CikloParking” web questionnaire for local self-government units do not keep records of spatial coverage with bicycle infrastructure” (n = 17 local self-government units)

*The mentioned results refer to a sample collected up to the time of writing the article (December 2023)

[The reform we are implementing together...](#) ●

06

RAZGOVOR S PROF. DR. SC. JASMINOM PAŠAGIĆ ŠKRINJAR,
PREDSJEDNICOM ORGANIZACIJSKOG ODBORA TRANSPORTIKUMA

Project TRANSPORTIKUM - Integration of Science and Economy

"The Transportikum project is an interdisciplinary program at the Faculty of Transport and Traffic Sciences, University of Zagreb, bringing together students with the aim of addressing real challenges in the field of transportation and logistics. Participants in the project apply theoretical knowledge gained during their studies to concrete tasks in the economic sector, collaborating with partner companies and relevant experts," highlighted Prof. Jasmina Pašagić Škrinjar, Ph.D., the president of the Organizing Committee of Transportikum, in a conversation.



Prof. Jasmina Pašagić Škrinjar, Ph.D.
jasmina.pasagic@fpz.unizg.hr

Can you briefly describe what the Transportikum project is and what makes it unique, what are the advantages of participation?

The Transportikum project combines science and economy, which is the only correct path for the development of technological processes. It allows students to promote themselves to potential employers and enables them to acquire additional competencies. Given that students from different faculties are involved, in interdisciplinary teams, they learn from each other's diverse knowledge and problem-solving approaches. For businesses, it provides proposals for solutions to specific challenges considered outside the system, in an unburdened and highly creative way that can be very productive.

For faculties, this is an opportunity to promote students and gain insights into real problems that become our scientific research subject. The uniqueness of this project lies in the large number of participants required for its realization, making it challenging and complex to coordinate. The Organizing Committee of the Transportikum project consists of Prof. dr. sc.

Danijela Barić, prof. dr. sc. Borna Abramović, Assoc. Prof. dr. sc. Željko Šarić, Martina Jakara, mag. ing. traff., Lucija Bukvić, mag. ing. traff. and Silvestar Grabušić, mag. ing. traff. They are all enthusiasts who selflessly dedicate their time to organizing and implementing the project.

Students invest a significant amount of their free time, but I am confident that their desire for



Final presentation of students' solutions to project partner companies of Transportikum

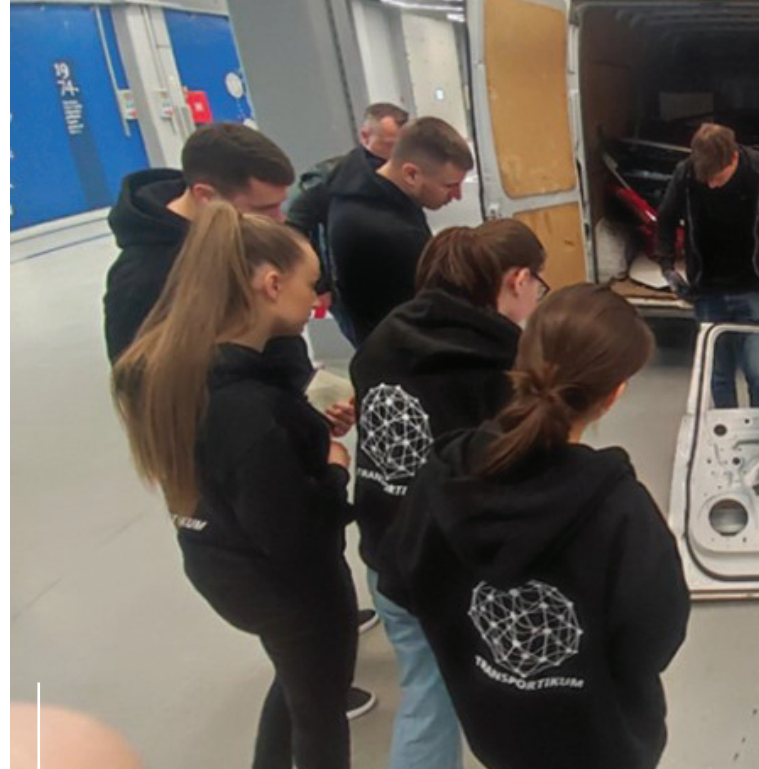
additional activities has resulted in gaining additional knowledge and skills. I wish them luck and hope they catch the attention of some of our industry partners because what we, as a faculty, are certain of is that the students participating in this project are exceptionally qualified future employees.

This project allows students to earn additional ECTS credits and monetary rewards for the winning team, amounting to 800 euros..

How does the implementation of this project look operationally?

Through regular meetings, field visits and consultations with representatives of project partner companies, students gain practical experience and develop key competencies necessary for future work in the industry.

This year, students from the Faculty of Traffic Sciences, Faculty of Electrical Engineering and Computing, Faculty of Civil Engineering, Faculty of Mechanical Engineering and Naval Architecture, Faculty of Science and Mathematics and the Faculty of Economics are involved in the project.



Field visits and consultations with representatives of partner companies are an integral part of participation in the project. Mr. Kristijan Oslić, the Director of the Abuse Prevention and Claims Processing Improvement Service from Croatia osiguranje, is pictured with the students



Field visit of project teams working on the task for the partner company INA

That's very interesting, how many students are participating this year and who are the partner companies?

A total of 97 students have registered, and this year's partners and their project tasks include some previous ones, but there are always new partners interested in this model of combining science and problem-solving in the industry. The companies participating and the topics of the tasks are as follows:

- Aircraft Accident Investigation Agency: Analysis of general aviation aircraft accidents in the Republic of Croatia
- Arriva Hrvatska: Development of a multimodal travel application model: MaaS solution for inter-city travel in the Republic of Croatia
- Atlantic Group: Outbound goods control process modeling
- Axereal: Planning and organization of cereal transportation
- Calla Logistics: Development of a concept for the education of professional drivers to prevent risky driving
- Coca-Cola: Optimization of logistical processes in the Zagreb distribution warehouse
- Croatia osiguranje: Autonomous systems on vehicles and the possibility of determining driving modes at the time of a traffic accident
- dm-drogerie markt d.o.o. Hrvatska: Route analysis, optimization and CO2 calculation



- DPD: Development of a methodology for calculating fair costs for partners delivering packages for DPD in Croatia
- Grawe Hrvatska: Analysis of traffic accidents involving vehicle collisions with wildlife
- HAKOM
 - Railway Services Sector: Proposal for a system of indicators for the quality of railway freight transport in Croatia
 - Postal Services Sector: The future of universal (postal) services for the next 10–20 years
- Hrvatska pošta (Croatian Post): Modernization of urban logistics: delivery, packaging and technological innovations
 - Advantages and disadvantages of delivery organizations using electric vehicles compared to thermal vehicles in densely populated urban areas
 - Robotics/automation of packing and dispatching shipments
- HŽ Putnički prijevoz: How to improve passenger transport services during special regulations in railway traffic
- INA: Optimization of secondary distribution
- Lider projekt: Proposal of new traffic solutions and simulation development in the Lušičić – city center coverage zone in Karlovac
- Zagrebačka pivovara: (Zagreb Brewery): System of raw materials and packaging materials
 - Automation of ordering raw materials and packaging materials
 - Truck tracking/tracing system for the delivery of raw materials and packaging materials

Is the project conducted every year? What do the project activities look like?

Yes, the project is conducted every year. Project activities begin at the start of the academic year in October and the final activities (presentation of project solutions and announcement of winning teams) take place in May.

During that period, teams organize field visits to the companies for which they are solving tasks. Communication regarding additional information and team questions is conducted through the Organizing Committee. If necessary, an additional meeting between teams and company representatives is arranged.

The review of project solutions and the creation of presentations for selected solutions take place at the end of April 2024. Attendance at the final event and the announcement of winners is in May 2024.

Can you conclude at the end of the conversation what are the primary benefits for the partner companies and the students involved in this project?

The goal of the project is to connect and collaborate between students and business professionals, allowing students to engage in practical work on real tasks from the business world and gain practical knowledge by addressing numerous challenges that companies face in their processes. This prepares students for the active application of acquired knowledge. For business professionals, it provides access to highly motivated, diligent and creative students, aiding them in selecting future quality personnel solutions. Student teams foster the development of innovations that can contribute to the economy, whether through process optimization, the application of new technologies or the improvement of logistics solutions. Students offer project solutions with the potential for implementation in real business environments, which is truly interesting for partner companies.



Consultations at the partner company and on-site inspection of processes

what students participating in the TRANSPORTIKUM project say about it

Gabrijela Ivanjko, FPZ, Traffic Studies,
Road Transport Speciality – Graduate Studies

„I believe that the Transportikum project is a fantastic opportunity for students. By engaging in different projects, you get a sense of how a company really operates and the issues employees deal with on a daily basis. I applied for the Transportikum project to gain new practical knowledge that provides me with a broader perspective in a professional sense. Transportikum is a project that often provides students with their first exposure to real issues faced by companies. I believe that, with their guidance and the knowledge we have gained during our studies, as well as the mentorship of professors, we can provide quality and applicable solutions in practice.

the company for which I am working on the project. Simultaneously, this provides me with an opportunity for better employment, offering experience and knowledge.

I applied for the Transportikum project to challenge myself in solving interesting problem tasks, acquire new practical knowledge that I hope will be beneficial in the future, and because last year, my team and I emerged as winners in one of the project tasks, and I hope for a similar outcome.

I believe that the benefits of applying to Transportikum include gaining knowledge about real-world business problems, networking with professionals, fostering competitiveness in problem-solving to achieve better solutions, and, with the assurance of a monetary reward for winning the project, finding motivation towards success.”

Dominik Knez, FPZ, Intelligent Transport Systems and Logistics, ITS Specialty – Graduate Studies

“My interest in participating in the Transportikum project primarily stems from the recommendation and encouragement of professors who motivated us to explore the opportunities that Transportikum offers. Additionally, there was curiosity about the specifics of the project tasks and group work with colleagues, which added an element of fun to the solution development process. Before applying, we didn't have a complete picture of what to expect, but after the first meeting and introduction to the project tasks, we noticed a task closely related to the theme of our final thesis. This prompted us to leverage the knowledge and developed applications from our theses to provide the most effective solution for the selected project task and achieve first place.



Student Gabrijela Ivanjko and her team with Mr. Domagoj Crnčić, Director of the Passenger Transport Sector at Arriva Hrvatska

The greatest benefit of my application is the opportunity to work in a team, highlighting my own creativity to achieve the ultimate goal. By working in a team, we complement each other with ideas and create a quality and applicable solution that will satisfy the company. Additionally, the motivating factors include extra ECTS credits and the opportunity for competition, which drives the entire team as well as individuals towards further progress and the ultimate goal of developing a high-quality solution selected as the winning one.”

Ivan Pehar, FPZ, Intelligent Transport Systems and Logistics, Logistics Specialty – Graduate Studies

“My expectations from Transportikum are to become acquainted with real-world issues in the fields of transport, logistics and business in general. I aim to learn new information, connect with professional business people, invest effort in researching and solving problems, and ultimately arrive at a solution that may assist



■ Student Dominik Knez with his team and Mr. Ivan Ramljak, Head of Transport for the Croatia and Slovenia region at Atlantic Group

By participating in the project, we have gained several significant benefits. Participation and winning first place provide us with an opportunity to enrich our resumes with prominent involvement in a project closely related to our field, showcasing our commitment to extracurricular activities. Additionally, the monetary reward for winning first place is a nice benefit that encourages participants to put maximum effort into their solutions. Although we have already completed the mandatory internship at the faculty, it is important to note that participation in the project is viewed as a completed internship, which can be of great benefit to students who have not yet completed their internship. Furthermore, the assigned 2 ECTS credits represent another benefit of participating in the project, which can be useful when applying for some form of scholarship."



● **Kristijan Oslić, Director of the Abuse Prevention and Claims Processing Improvement Service at Croatia osiguranje**

The Transportikum project was a unique opportunity to introduce students to advanced technologies and the digital agenda in claims processing, which particularly intrigued them and ultimately sparked their interest in our project tasks. When devising and defining project tasks, our goal was to connect real issues arising from existing processes with the available space for students' research and

industry industry commentary commentary

the application of expertise gained during their studies. This aimed to stimulate students' creativity in proposing solutions. In this regard, we were most impressed by the proactivity of the students and their interest, which often went beyond the framework of the assigned tasks. Ultimately, the proposed solutions to project tasks, depending on their applicability, were implemented in our daily processes, contributing to the improvement of claims processing and enhancing the overall customer experience. Furthermore, after the project's completion, valuable connections were maintained with the students, and doors were left open for any future collaborations, knowledge acquisition and exchange. ●

07

Waste Management Analysis and Complexity

PRIPREMILA:

Paula Rukljač, mag. ing. traff.
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Waste management is an important issue in both developed and developing countries, with a focus on efficient organization for sustainable reasons. Well-established waste management models significantly impact the quality of life, financial viability and ecological usability of recycled materials. Continuous analysis of existing processes is crucial for optimization endeavors

Waste, if not handled properly, can harm the environment to varying degrees. Waste management involves processes, techniques and technologies aimed at directing reduced quantities to landfills. Sustainability in waste management results in transparent processing and the ability to track the amounts recycled or directed to landfills.

The primary goal of reorganizing waste management systems is to reduce the quantities directed to landfills. Prevention of waste generation and facilitating proper reuse, along with determining materials for the production of goods, is essential. Public education is also significant in waste management, as evidenced by studies in Western European countries that have implemented various educational methods.

In recent times, there has been a growing awareness of the importance of environmental preservation and biodiversity. Consequently, some European countries have developed highly effective waste disposal and recovery systems, providing inspiration for improving the waste management system in the City of Zagreb.

Good examples of waste management can be found in the Republic of Italy, the Kingdom of Denmark, the Kingdom of Sweden and the Republic of France.

Italy's Capannori municipality boasts one of the highest rates of recycled waste in Europe, a result

of residents' opposition to waste incineration. The town joined the "Zero Waste" project in 2007, committing to reduce landfill waste to zero by 2020. The "door-to-door" waste collection was introduced gradually between 2005 and 2010, starting from small villages, where errors could be immediately identified and corrected, and later expanded to the entire municipality. Substantial results were achieved by 2010, with 82% of household waste being sorted, leaving only 18% for landfill disposal. A microchip payment system on waste bags, scanned by the collection truck, further increased waste sorting to 90%.

The authors of the study emphasize the significant role played by volunteers in achieving such a high percentage of sorted waste. Volunteers underwent training before the system was introduced and were prepared to answer all citizen questions, resolve any uncertainties and distribute free waste separation kits. In addition, community gatherings were organized where education and counseling on waste separation took place. The first "Zero Waste" research center was established, where experts studied items still being discarded as mixed waste. It was found that the most commonly discarded unsorted items were coffee capsules and disposable baby diapers. Armed with this knowledge, scientists reached out to companies like Nespresso and Illy to find solutions, such as introducing biodegradable and recycled

materials into capsule production. When it comes to the issue of disposable diapers, the municipality offered subsidies to residents who chose to purchase reusable diapers. Alongside the research center, a "Reuse Center" was opened, where used items such as clothing, shoes, toys, electrical appliances and furniture could be repaired or modified and sold at affordable prices.

The Kingdom of Denmark has achieved impressive results in recovering and recycling various types of waste, especially construction and demolition waste. The country faces excess waste incineration capacity due to increased waste sorting and recycling. Existing waste incineration plants generate about 20% of central heating and 5% of electricity consumption in the country. If less waste is processed than incineration plants are designed for, the costs of incineration significantly increase. Consequently, the Kingdom of Denmark imports large quantities of waste for incineration.

Moreover, there is a circular economy strategy adopted in 2018. One of the most intriguing projects of this kind is the Kalundborg Park, where a partnership has been established among nine public and private companies. The main principle is that the waste from one company becomes a resource for another, benefiting both the environment and the economy. Such symbiosis creates growth in the local area and supports the efforts of companies in socially responsible business practices while mitigating the impact of climate change.

In the Republic of France, measures are being taken to reduce food waste, considering that 10 million tons of food are discarded annually. In 2018, France became the first country in the world to ban supermarkets from throwing away or destroying unsold food. Instead, they are "forced" to donate surplus food to charitable organizations and food banks. The prohibition of excess food disposal in supermarkets requires every store with an area greater than 4,305 m² to sign donation agreements with nonprofit organizations. Otherwise, companies face fines of up to 75,000 euros and responsible individuals may even receive prison sentences of up to two years.

The Kingdom of Sweden firmly holds the status of a country with the best systems and processes for collecting, recycling and recovering waste materials. By 2020, Sweden achieved almost zero waste levels, meaning it recycles 99% of local waste and has imported around 2 million tons of waste from other European countries. The primary reasons for this success lie in the awareness and education of the residents of the Kingdom of Sweden, followed by sophisticated waste collection and processing techniques and government support. Sweden did not achieve this overnight. It involved years of work, effort, desire and significant financial resources primarily coming from the state, cities, municipalities, etc. Their priority from the start is to adapt production and processes to make products environmentally friendly throughout their life cycle. According to the legislation of this country, all municipalities are responsible for handling municipal waste as well as household waste. In many cases where population density is higher, municipalities contract external companies engaged in waste collection and transportation to perform these tasks for them. As early as 1993, the southwestern Swedish region of Scania used the majority of household waste and some industrial waste as fuel in a central incineration plant, producing approximately 500 GWh of hot water per year. This energy served to heat about 25% of Malmö. Twenty years later, this figure increased to 1.4 TWh of heat, supplying 60% of all heating needs for Malmö and Burlöv, as well as 250 GWh of electrical energy.

Another good example of waste management comes from the City of Lund, where sorting is facilitated by two bins divided into four compartments. The first bin is designated for the separation of plastic, colored glass, food residues and household waste, while the second bin is intended for paper, transparent glass, metals and cardboard. Accordingly, vehicles with cargo compartments divided into four sections have been developed to collect waste from



The poster "Kad se zgužva, nije gužva"
["When you crumple it, more can fit"]
Source: author, 22 January 2023.



Overflowing containers in Zagreb
Source: author

each bin simultaneously. In addition, these cargo vehicles are powered by biogas generated from food waste.

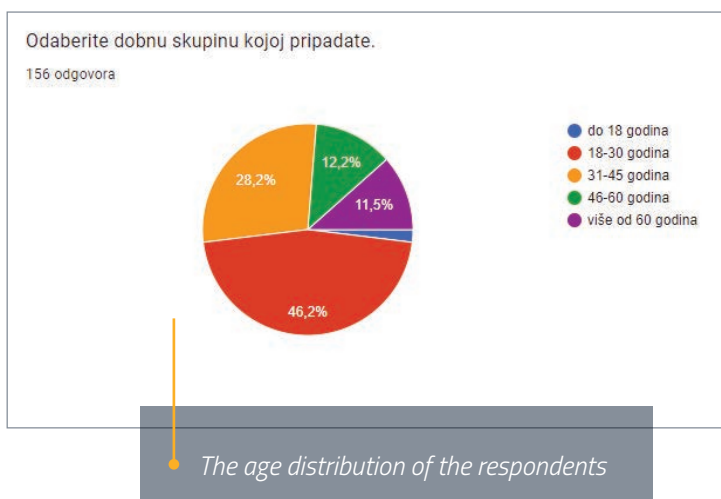
The following is an analysis of the new waste collection and billing model in Zagreb. To assess the results of the new model, a survey was conducted among citizens and the results are presented. The goal is also to create a knowledge base that can be used to improve the model based on examples from other European cities and the opinions of citizens who have been involved in the implementation of the waste separation, collection and billing model from the beginning.

On 1 October 2022, a new model for the collection and billing of mixed waste was introduced in Zagreb. There were no changes in the collection and disposal of recyclable waste (paper, plastic, metal, glass packaging and organic waste). However, for mixed municipal waste, special bags, called ZG bags, were introduced. The new model eliminates the previous method of billing based on the number of residents in the household and the square footage of the apartment. Instead, it introduces billing based on the actual quantity of generated mixed municipal waste. In this way, citizens pay for the service of disposing of mixed municipal waste based on the amount they have generated, further incentivizing them to separate recyclable waste. In addition, infographics and posters have been made available to encourage citizens to sort their waste to the greatest extent possible (visible in the image below). Unlike the previous waste collection billing system, which did not encourage citizens to separate useful waste, the goal of the new model for collecting mixed municipal waste is to reduce the amount of disposed waste and increase the amount of useful waste.

According to the current schedule in settlements outside the city center, mixed waste and organic waste are collected once a week, while paper and plastic waste are collected every other week alternately. Due to the current waste collection schedule, containers are often overflowing. This is evident in several photos below, taken in different neighborhoods in Zagreb.

To analyze the real opinions of citizens and their satisfaction with the new system, a survey was conducted in the form of a Google Form. The survey took place from 30 April 2023 to 28 June 2023. A total of 156 respondents participated out of the 352 to whom the inquiry was sent. The age distribution of the respondents is shown in the graph below. Of the total number of respondents, 64% live in residential buildings, while the remaining respondents live in family houses.

Out of the total number of respondents, 84% of those living in family houses stated that they use ZG bags for disposing of mixed municipal waste. One-fifth, or 20% of respondents, mentioned that they were almost entirely separating waste even before the introduction of ZG bags, and after the introduction of ZG bags, this percentage increased to 45% (graphs below; 1-not at all, 10-completely). More than 30% of respondents state that they do not consider the new waste collection billing system fairer than the previous one.



Participants living in family houses believe that mixed municipal waste is not collected frequently enough, along with other types of waste. When asked what would encourage them to separate waste more, most of them responded that more frequent waste collection and collective awareness of recycling would be motivating factors.

A majority of participants live in residential buildings and dispose of waste in separate containers and dumpsters located within or in the immediate vicinity of the building. 66% of these respondents stated that they always use ZG bags for disposing of mixed municipal waste. Only 20% of respondents mentioned that they did not separate waste at all before the introduction of ZG bags and this percentage decreased to 8% after the introduction of ZG bags. Moreover, the percentage of those who almost completely or completely separate waste increased twofold before

and after the introduction of ZG bags. These survey results are also depicted in the graphs below (1-not at all, 10-completely)

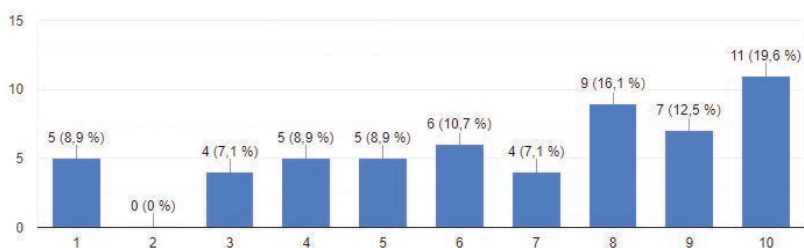
The respondents living in both family houses and residential buildings agree that the new waste collection billing system is not fairer than the previous one. According to the respondents, mixed waste is collected the least regularly and causes the most significant issues. Following mixed waste, plastic waste is considered by 35% of respondents to not be collected frequently enough. About 30% of respondents unanimously believe that paper and organic waste are not collected frequently enough, but they still consider the collection schedule more suitable than for mixed and plastic waste.

The majority of respondents state that they frequently encounter full containers when disposing of waste and that they would be more motivated to separate waste if the containers were not overflowing during disposal. When asked what would encourage them to separate waste more, over 60% of respondents answered that it is the collective awareness of citizens about recycling. They find it very demotivating when individuals make an effort to sort waste and use ZG bags, while others neither sort waste nor use ZG bags and face no sanctions.

The examples of the Italian municipality Capannori and the Kingdom of Sweden illustrate that education is the most crucial aspect of waste sorting at its source, significantly contributing to recycling and recovery opportunities later on. Advanced waste collection and processing techniques, as well as government support, come after public awareness and education. Entire systems rely on proper sorting where waste is generated, such as in households. Citizens need to be shown good examples of how things no longer in use can be "brought back to life" or repurposed. Additionally, it is necessary to demonstrate to citizens that their efforts are worthwhile and that different types of waste are not disposed of in the same place after collection. Although citizens initiate actions like collecting toys, clothing, etc., when there is a need, the city's participation in these initiatives would undoubtedly further motivate citizens. ●

U kojoj ste mjeri odvajali otpad **prije** uvođenja ZG vrećica?

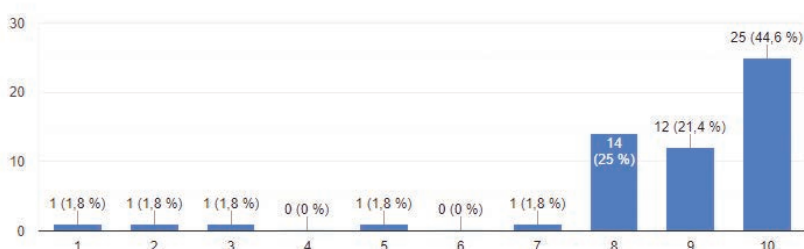
56 odgovora



Separation of waste by residents of family houses before the introduction of ZG bags

U kojoj mjeri odvajate otpad **nakon** uvođenja ZG vrećica?

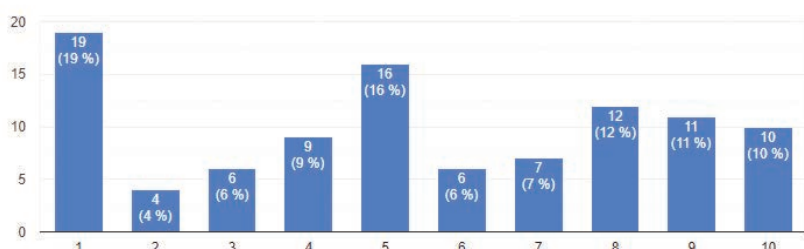
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Separation of waste by residents of family houses after the introduction of ZG bags

U kojoj ste mjeri odvajali otpad **prije** uvođenja ZG vrećica?

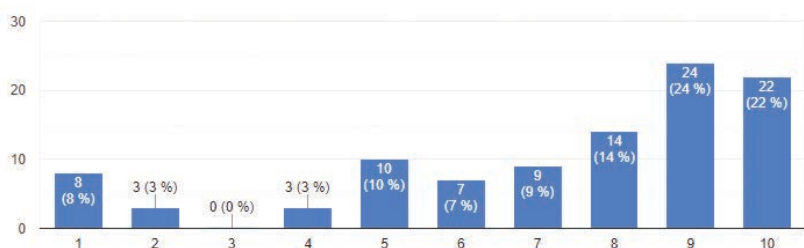
100 odgovora



Separation of waste by residents of apartment buildings before the introduction of ZG bags

U kojoj mjeri odvajate otpad **nakon** uvođenja ZG vrećica?

100 odgovora



Separation of waste by residents of apartment buildings after the introduction of ZG bags

08

JOIN US AT THE 21st INTERNATIONAL CONFERENCE
ON TRANSPORT SCIENCE (ICTS 2024)

21st International Conference on Transport Science (ICTS 2024)



PRIPREMILA:

Asst. Prof. Patricija Bajec, Ph.D.
patricija.bajec@fpp.uni-lj.si

The Slovene Association of Transport Sciences, in collaboration with the University of Ljubljana's Faculty of Maritime Studies and Transport, is organizing the 21st International Conference on Transport Science (ICTS 2024) in May in beautiful Portorož, Slovenia

The Slovene Association of Transport Sciences, in collaboration with the University of Ljubljana's Faculty of Maritime Studies and Transport, is thrilled to invite you to the 21st International Conference on Transport Science (ICTS 2024). The event will take place on the **20 and 21 May 2024** at the Grand Hotel Bernardin in Portorož, Slovenia.

Join Us at the 21st International Conference
on Transport Science (ICTS 2024.)



WHAT TO EXPECT?

DIVERSE TOPICS: Explore a wide range of topics, including ecology and transport, education in transport, human resources in transport, intelligent transport systems, intermodal transport, logistics in transport, maritime sciences, maritime and transport law, urban mobility, public transport, safety and security in transport, terminology in transport, transport in space, transport economics, transport engineering and technology, transport infrastructure, transport management, transport optimization, transport planning and urban distribution.

INTERNATIONAL COLLABORATION: UEngage with around 150 participants from diverse countries, representing both academia and the business world.

MEDIA COVERAGE: The event will be covered by the media.

CONFERENCE HIGHLIGHTS

THEMATIC SECTIONS: Delve into specific themes with special thematic sections and roundtable discussions.
STUDENT KNOWLEDGE EXCHANGE: See students from UL EF, UM FGPA and UL FPP in a knowledge competition.

SPONSORSHIP OPPORTUNITIES

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EXTENDED VISIBILITY: Logos will remain on the conference website for approximately four years, ensuring long-term exposure.

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For inquiries, contact the official conference e-mail: icts@sdzp.org

DON'T MISS THIS OPPORTUNITY TO BE PART OF AN
EXCHANGE OF IDEAS AND INNOVATIONS IN THE FIELD
OF TRANSPORT SCIENCE. JOIN US AT ICTS 2024
AND CONTRIBUTE TO THE ADVANCEMENT OF KNOWLEDGE
IN MARITIME, TRANSPORT AND LOGISTICS SCIENCES



09

JOIN US AT THE 18th INTERNATIONAL CONFERENCE
ON AGRICULTURAL LOGISTICS

Logistics in Agriculture



PRIPREMIO:

Prof. Andrej Lisec, Ph.D.
andrej.lisec@vsgrm.unm.si

The international scientific conference on the highly important and interesting topic of logistics in agriculture is taking place in the Republic of Slovenia at the Landscape Governance College Grm Novo mesto.

Logistics in Agriculture is a traditional scientific conference in logistics with a connection to agriculture. The 17th International Conference on Agricultural Logistics was organized by: Landscape Governance College Grm Novo mesto, the Municipality of Sevnica, Faculty of Logistics, University of Maribor, Grm Novo mesto – Center of Biotechnology and Tourism, Cooperative Union of Slovenia and Faculty of Organization Studies. The central theme of this year’s conference was “Climate Changes of Logistics in Agriculture”.

The conference has become traditional and paves the way for a different view of logistics in connection with agriculture. The keynote speaker was Prof. Lučka Kajfež Bogataj, PhD with the theme Climate Change and Logistics – It Is Necessary to Adapt to a New Climate. Climate change is a reality all over the world. The range of stations is ever-increasing, and changes are ever faster. The last decade was the warmest on record in Europe measured. The average air temperature in Europe is now 1.3°C higher than in the pre-industrial era. The atmosphere temperature



17th International Conference on Agricultural Logistics



Lučka Kajfež Bogataj, Ph.D. with the theme Climate Change and Logistics



Managing logistic processes is specific and often requires the adaptation of logistics equipment with the aim of preserving quality

in Slovenia was as much as 1.8°C above that in the last 20 years in the 20th century. Agriculture is already feeling the harmful effects of climate change. Extreme weather conditions, including flooding, droughts, storms and heat waves in many parts of the EU also due to ill-adjusted logistics cause economic losses to farmers and the EU agricultural sector.

The papers that were presented at the conference were: Examining the Environmental Awareness of Rural Households in Terms of Household Waste Management and Purchasing Decisions, authors:

Katalin Mészáros, Nikoletta Németh, Attila Kurucz; The Role of MES in Supporting the Implementation of Circular Economy Practices, author: Slobodan Antić; Multicriteria Decision Making for the Selection of Agri-Food Service Providers, authors: Jabir Arif, Fouad Jawab; The Impact of Climate Change on the Quality of Wine Production – Development of a System Dynamics Model, authors: Maja Borlinič Gačnik, Andrej Škraba, Črtomir Rozman and Boris Prevolšek; Yachting's Role in Advancing Sustainable Eco Logistics, authors: Todor Mitkov, Tihomir Dovramadžiev; Fostering Sustainable Wine Tourism through Collaboration of Grape Growers and Winemakers: Case of Ljutomer-Ormož Hills, authors: Tomi Špindler, Nejc Pozvek and Marko Koščak; Effective Education for Green Passage, Competences for Sustainability and Project Work with Students, author: Jasna Potočnik Topler; Rural Transformation Supply Chain: Exploitation of Artificial Intelligence for Optimization of Agricultural Logistics, authors: Nejc Podkoritnik and Andrej Lisec; Self-Reflection of Family Farms on Their Own Activity, authors: Mirjana Medja, Maša Vidmar and Lea-Marija Colarič-Jakše; Cooperative Models in Sustainability-Oriented Communities, authors: Barbara Grntal and Lenka Puh; Customization of Tourists Farm for People with Disabilities, authors: Larisa Podržaj, Anamarija Ristič and Lea-Marija Colarič-Jakše. ●

THE NEXT 18TH INTERNATIONAL CONFERENCE
ON AGRICULTURAL LOGISTICS WILL DEAL WITH THE THEME
WORLD CHALLENGES IN LOGISTICS IN AGRICULTURE
AT THE LANDSCAPE GOVERNANCE COLLEGE GRM NOVO
MESTO ON 7 NOVEMBER 2024 AT 10.00.

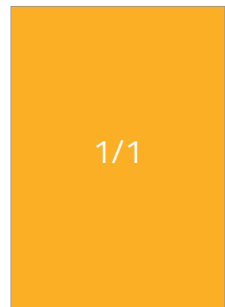


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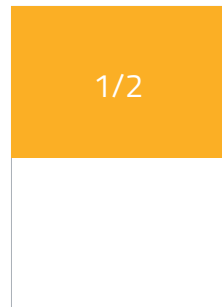
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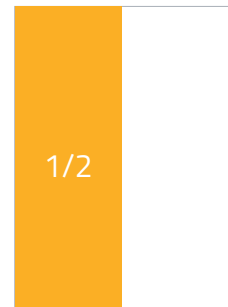
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10,5 x 29,7 cm

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