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# Nauka i tehnologija



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# NAUKA I TEHNOLOGIJA

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## Words from the Editor

Welcome to the latest edition of *Nauka i tehnologija / Science and Technology*, the esteemed scientific journal of the International University Travnik in Travnik. Published biannually, our journal is dedicated to addressing pressing issues in the fields of social, artistic, and technical sciences with a blend of scientific rigor and professional insight.

Our mission is to engage our readers with groundbreaking ideas and goals from these diverse areas, fostering a deeper understanding and appreciation of the advancements shaping our world. Each issue of *Nauka i tehnologija* offers a platform for scholars and professionals to share their innovative research and thought-provoking perspectives. We take pride in featuring not only original scientific and professional papers but also comprehensive review papers and insightful conference proceedings.

As a testament to our commitment to excellence, *Nauka i tehnologija* is indexed by several prominent services, including Google Scholar, Scilit, Dimensions, Semantic Scholar, Lens.Org, J-Gate, ErihPlus, Road, Open Alex, EconBiz, Ceeol, Miar and Index Copernicus. This ensures that the valuable contributions of our authors are accessible to a wide audience, amplifying the impact of their work.

In this edition, Vol. 14, No. 1, 2026., we are proud to present a diverse array of papers that reflect the broad scope of our journal:

1. **Žana Arsić and Ana Lojić**, in the paper **"Digitalization of the Craft and Entrepreneurial Sector: Legal, Technological and GDPR Challenges,"** write about the digitalization of the craft and entrepreneurial sector, focusing on the legal, technological, and GDPR-related challenges of digital transformation.
2. **Božo Vukoja, Antonio Vukoja, and Matea Antonela Vukoja**, in the paper **"Application of the Three Lines of Defense Model in Internal Audit in BiH,"** write about the application of the Three Lines of Defense model in internal audit in Bosnia and Herzegovina and its role in risk management.
3. **Kasim Bajramović, Irhad Bajramović, and Irfan Bajramović**, in the paper **"The Influence of Physico-Chemical and Environmental Factors on the Explosibility of Coal Dust and Prevention Measures,"** write about the influence of physico-chemical and environmental factors on the explosibility of coal dust and the corresponding prevention measures.
4. **Alma Destanović**, in the paper **"Consular Function in the Context of the Vienna Convention,"** writes about consular functions within the framework of the Vienna Convention and their significance in international law.
5. **Rifat Samet Yazıcı and Matevž Obrecht**, in the paper **"Spatial Analysis of Disaster Logistics in Slovenia: A Case Study of Celje and the 2023 Floods,"** write about the spatial analysis of disaster

logistics using the 2023 floods in Celje as a case study.

6. **Tarik Ejubović**, in the paper "**A Model of Lifelong Traffic Education as a Foundation for Proactive Road Safety**," writes about a model of lifelong traffic education as a foundation for improving road safety.
7. **Mujo Mališević**, in the paper "**Transformation of Conventional Road Infrastructure into Intelligent Roads: Technological Framework and Functionalities**," writes about the transformation of conventional road infrastructure into intelligent roads, highlighting their technological framework and functionalities.
8. **Rudolf Petrušić and Nera Akrap**, in the paper "**The Impact of Generative Artificial Intelligence on the Business Processes of Small and Medium-Sized Enterprises**," write about the impact of generative artificial intelligence on the business processes of small and medium-sized enterprises.
9. **Elmida Burina**, in the paper "**The Rule of Law in the Process of European Integration of Bosnia and Herzegovina: A Legal Criterion or a Political Challenge?**" writes about the role of the rule of law in the European integration process of Bosnia and Herzegovina, examining whether it represents primarily a legal criterion or a political challenge.

Thank you for your support and interest in *Nauka i tehnologija*. We look forward to presenting you with the latest advancements and discussions in the upcoming issues.

Sincerely,

**Editor-in-chief**

**Prof. dr. sc. Cariša Bešić**



## DIGITALIZATION OF THE CRAFT AND ENTREPRENEURIAL SECTOR: LEGAL, TECHNOLOGICAL AND GDPR CHALLENGES

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### Abstract

*Digital transformation of the craft and entrepreneurial sector is an important prerequisite for improving competitiveness, service availability and the long-term sustainability of micro and small business entities. This paper examines the digitalization of craftspeople and self-employed entrepreneurs through the use of digital tools for administration, client communication, service promotion and simplified business process management. Special attention is given to legal challenges accompanying this transformation, particularly personal data protection, lawfulness of processing, transparency and information system security in accordance with the principles of the General Data Protection Regulation. The research is based on an anonymized survey of 150 respondents, processed in a Python environment through descriptive statistics, correlation analysis and segmentation using the Digital Readiness Index and the General Compliance Index. The results indicate partial digitalization, strong reliance on social media and a clear gap between digital tool use and written privacy rules. The contribution of the paper is a practical support model for chambers, institutions, IT experts and entrepreneurs moving toward sustainable and compliant digital business.*



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# 1. INTRODUCTION

## 1.1. Research context

The digital transformation of micro and small business entities increasingly determines their ability to respond to client needs, accelerate administrative procedures and increase market visibility. Craftspeople and self-employed entrepreneurs have a specific role in local economic development because they provide direct services to citizens and often operate with limited human, financial and technological resources. For this reason, digitalization in this sector cannot be viewed only as the technical introduction of software or online channels. It is an interdisciplinary process that includes business models, legal security, personal data protection and the development of digital competences.

The analysis presented in this paper was carried out in February 2026 on an anonymized dataset collected through a Google Forms questionnaire. The questionnaire focused on the use of basic digital tools, the level of knowledge of data protection obligations and the expressed need for training. The data were processed in a Python environment, where two composite indicators were calculated: the Digital Readiness Index (DRI) and the General Compliance Index (GCI).

## 1.2. Aim and research questions

The aim of the paper is to determine, through a legal and technological approach, the level of digital maturity of the craft and entrepreneurial sector and to identify the areas in which targeted support by chambers, institutions and professional organizations is needed. The research questions are: (1) What is the level of digital maturity among the surveyed entities? (2) Does technological adoption correspond to basic legal compliance? (3) Which areas show the largest gap? (4) Which groups have the greatest need for education and institutional support?

# 2. THEORETICAL AND LEGAL FRAMEWORK

## 2.1. Self-employed entrepreneurs and areas of activity

The legal framework of the Republic of Srpska recognizes a self-employed entrepreneur as a natural person performing a registered market activity for profit. The Law on Self-Employed Entrepreneurs of the Republic of Srpska regulates business characteristics, registration, register management, the organization of entrepreneurs, craft activities and other issues relevant to entrepreneurial operations (Republic of Srpska, 2024). For the purposes of this paper, areas of activity were grouped according to the legal and statistical framework, with reference to the Classification of Activities of the Republic of Srpska 2010, which is based on the European NACE Rev. 2 classification and harmonized with classifications at the level of Bosnia and Herzegovina (Agency for Statistics of Bosnia and Herzegovina, 2010; Republic Institute of Statistics of the Republic of Srpska, 2010).

*Table 1. Areas of activity used for classifying responses (Source: Authors)*

| Area of activity                   | Explanation for the research                                                                |
|------------------------------------|---------------------------------------------------------------------------------------------|
| Craft production and processing    | Production, processing and small craft manufacturing.                                       |
| Personal and other craft services  | Direct services to citizens, including repair, cosmetic, hairdressing and related services. |
| Traditional and artistic crafts    | Traditional skills, handmade products and household or workshop-based production.           |
| Construction and specialized works | Construction, finishing works, installation and related services.                           |
| Trade and repair                   | Trade in goods, repair and maintenance activities.                                          |
| Hospitality and food services      | Accommodation, food preparation and serving.                                                |
| ICT and professional services      | Information technology, technical, business and consultancy services.                       |

## 2.2. Digitalization and personal data protection

Digitalization in the craft and entrepreneurial sector most often begins with the use of social media, electronic communication, photographs of work, online orders, appointment records or simple invoicing software. Although these are basic tools, they frequently involve the processing of personal data, such as a client name, telephone number, e-mail address, photographs, order data or information about requested services. The introduction of digital tools should therefore be accompanied by transparent information for clients, purpose limitation, basic security measures and clear retention rules (European Parliament and Council, 2016; European Data Protection Board, 2023).

From the perspective of a chamber, the main challenge is not only to increase digital use, but also to provide simple legal templates and practical instructions that are understandable to micro entities. This includes short privacy notices, consent forms where necessary, social media guidance and security instructions for the use of software and online communication.

## 3. RESEARCH METHODOLOGY

### 3.1. Survey design and sample description

The research was conducted in February 2026 through a Google Forms questionnaire. An anonymized set of 150 valid responses from craftspeople and self-employed entrepreneurs was used for processing. Direct identifiers, such as name and surname, exact address, telephone number and e-mail address, were not included in the analytical dataset. The data were analyzed at an aggregated level, and variables were coded numerically for processing in Python.

Table 2. Variables in the anonymized survey dataset  
(Source: Authors)

| Variable            | Type        | Range/categories       |
|---------------------|-------------|------------------------|
| sector              | categorical | grouped activity areas |
| number_of_employees | numeric     | 0-5                    |
| uses_website        | binary      | 0 = no, 1 = yes        |

|                        |        |                 |
|------------------------|--------|-----------------|
| uses_social_media      | binary | 0 = no, 1 = yes |
| uses_online_payment    | binary | 0 = no, 1 = yes |
| uses_business_software | binary | 0 = no, 1 = yes |
| collects_client_data   | binary | 0 = no, 1 = yes |
| has_privacy_policy     | binary | 0 = no, 1 = yes |
| knows_gdpr_obligations | Likert | 1-5             |
| digital_readiness      | Likert | 1-5             |
| training_need          | binary | 0 = no, 1 = yes |

Based on these variables, an analytical processing flow was defined. It included the collection of responses, anonymization, database preparation, calculation of the DRI and GCI indicators and visualization of results in Python. The procedure is shown in Figure 1.



Figure 1. Flowchart of data collection, anonymization and Python processing (Source: Authors)

### 3.2. Indices and analytical procedure

The Digital Readiness Index (DRI) was calculated as the average of four binary variables: having a website, using social media, enabling online payment and using business software. The index value ranges from 0 to 1:

$$DRI_i = (website_i + social\_media_i + online\_payment_i + business\_software_i) / 4$$

The General Compliance Index (GCI) was calculated as a weighted combination of the existence of a privacy policy, the level of knowledge of GDPR obligations and lower exposure among entities that do not collect client data:

$$GCI_i = 0.40 \times privacy\_policy_i + 0.35 \times (GDPR\_knowledge_i / 5) + 0.25 \times (1 - client\_data_i)$$

The analysis was performed using pandas, numpy, matplotlib and scikit-learn. Descriptive statistics, correlation analysis and segmentation according to readiness levels were applied.

## 4. RESULTS

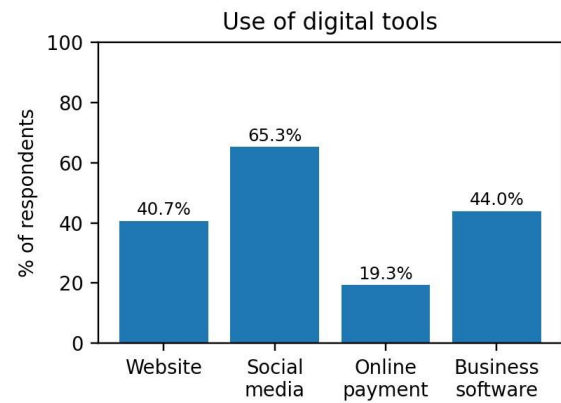
### 4.1. Descriptive statistics

This section presents the basic descriptive indicators for the main variables used in the analysis. The objective is to obtain an initial insight into the sample structure, the level of use of digital tools, the extent of client data collection and the basic elements of compliance with data protection principles.

*Table 3. Descriptive statistics of key variables (N = 150; Source: Authors)*

| Variable               | Mean | Std. dev. | Min  | Max  |
|------------------------|------|-----------|------|------|
| number of employees    | 1.35 | 1.41      | 0.00 | 5.00 |
| uses website           | 0.41 | 0.49      | 0.00 | 1.00 |
| uses social media      | 0.65 | 0.48      | 0.00 | 1.00 |
| uses online payment    | 0.19 | 0.40      | 0.00 | 1.00 |
| uses business software | 0.44 | 0.50      | 0.00 | 1.00 |
| collects client data   | 0.65 | 0.48      | 0.00 | 1.00 |
| has privacy policy     | 0.20 | 0.40      | 0.00 | 1.00 |
| knows GDPR obligations | 2.32 | 1.13      | 1.00 | 5.00 |
| digital readiness      | 2.74 | 1.11      | 1.00 | 5.00 |
| DRI                    | 0.42 | 0.23      | 0.00 | 1.00 |
| GCI                    | 0.33 | 0.20      | 0.08 | 0.92 |

The average DRI value in the sample is 0.42, indicating a low to moderate level of digital maturity. The average GCI value is 0.33, which shows that some entities use digital channels without sufficiently developed written privacy rules. The most commonly used digital tool is social media (65.3%), while online payment is the least represented (19.3%).



*Figure 2. Share of respondents using selected digital tools (Source: Authors)*

### 4.2. Digital readiness by area of activity

The distribution of respondents by DRI categories and areas of activity makes it possible to identify sectors in which digitalization is more developed and those in which additional support and education are needed.

*Table 4. DRI categories by area of activity (Source: Authors)*

| Area                               | Low   | Moderate | Medium | High  |
|------------------------------------|-------|----------|--------|-------|
| Construction and specialized works | 72.4% | 27.6%    | 0.0%   | 0.0%  |
| ICT and professional services      | 5.9%  | 23.5%    | 41.2%  | 29.4% |
| Personal and craft services        | 44.4% | 50.0%    | 5.6%   | 0.0%  |
| Trade and repair                   | 34.6% | 38.5%    | 23.1%  | 3.8%  |
| Hospitality and food               | 35.0% | 55.0%    | 10.0%  | 0.0%  |
| Craft production and processing    | 59.1% | 27.3%    | 13.6%  | 0.0%  |

The highest level of digital maturity appears among ICT and professional services, while construction and traditional personal services are more frequently placed in lower categories. This finding suggests that education should not be designed identically for all areas of activity, but tailored to the processes and digital habits of each group.

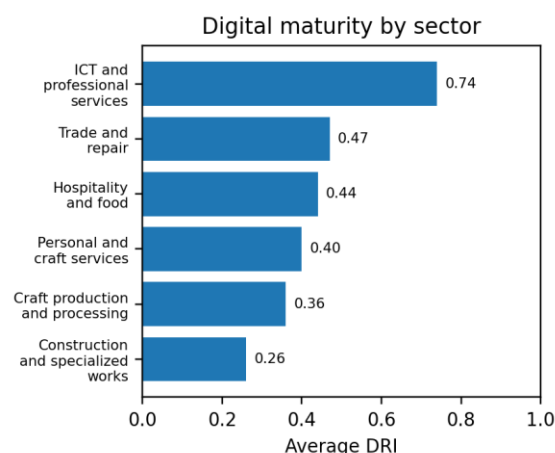


Figure 3. Average Digital Readiness Index by area of activity (Source: Authors)

### 4.3. Data protection compliance and correlation analysis

In the analyzed sample, 65.3% of entities collect client data, while only 20.0% have a privacy policy or a similar written notice. This ratio indicates the need for legal and information support through short templates, practical explanations and sector-specific guidelines.

Table 5. Pearson correlations between selected variables (Source: Authors)

| Variable pair                | r     | Interpretation     |
|------------------------------|-------|--------------------|
| DRI - GDPR knowledge         | 0.01  | very weak          |
| DRI - privacy policy         | 0.09  | very weak          |
| client data - GDPR knowledge | -0.00 | no linear relation |
| DRI - GCI                    | 0.08  | very weak          |
| digital readiness - DRI      | 0.74  | strong positive    |

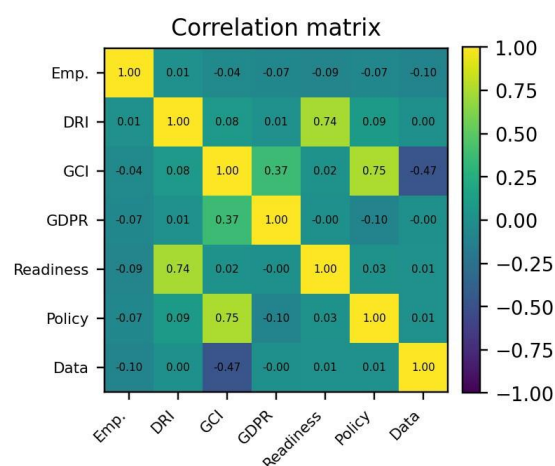


Figure 4. Correlation matrix of key variables (Source: Authors, Python processing)

The correlation between self-assessed digital readiness and the DRI confirms that respondents largely recognize their own digital maturity. At the same time, the weak relationship between DRI and GCI shows that technological progress does not automatically produce legal compliance. Digital and legal education should therefore be planned jointly.

### 4.4. Cluster analysis and comparative positioning

To understand differences among respondents more precisely, a cluster analysis was applied using DRI and GCI values. The entities were grouped according to the level of digital and legal readiness.

Table 6. Characteristics of digital readiness clusters (Source: Authors)

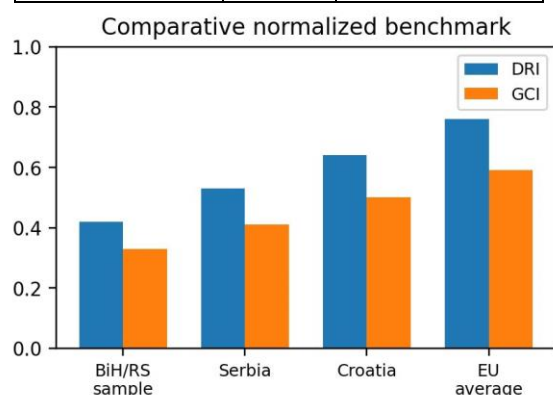
| Cluster          | Share | DRI  | GCI / training need |
|------------------|-------|------|---------------------|
| Low readiness    | 36.0% | 0.20 | GCI 0.24 / 72.2%    |
| Medium readiness | 48.7% | 0.47 | GCI 0.36 / 67.1%    |
| Higher readiness | 15.3% | 0.78 | GCI 0.49 / 52.2%    |

After the clusters were identified, the results were compared with indicative normalized benchmark values for Serbia, Croatia and the average of the European Union in order to place the BiH/RS sample in a wider regional and European context. The comparison is not an official statistical

ranking, but an analytical orientation for support measures and realistic development targets.

*Table 7. Comparative normalized benchmark of DRI and GCI (Source: Authors)*

| Area          | DRI  | GCI  |
|---------------|------|------|
| BiH/RS sample | 0.42 | 0.33 |
| Serbia        | 0.53 | 0.41 |
| Croatia       | 0.64 | 0.50 |
| EU average    | 0.76 | 0.59 |



*Figure 5. Comparative benchmark: BiH/RS sample, Serbia, Croatia and EU average (Source: Authors, normalized research overview)*

The comparative presentation indicates that the observed BiH/RS sample is approximately 20% lower than the indicative benchmark for Serbia, while Croatia and the EU average are significantly better positioned. This gap supports the need for targeted interventions that combine technology adoption with privacy and security guidance.

## 5. DISCUSSION

The results confirm the basic assumption of the paper: digitalization of the craft and entrepreneurial sector cannot be viewed only as a technical matter of software procurement or the opening of social media profiles. A digital channel often becomes a place for client communication, promotion of work, receiving orders and recording data. Therefore, every digital step also raises issues of legal certainty, transparency and responsibility in data processing.

From the legal perspective, the most important finding is the low share of entities that have a privacy policy or written information for clients. From the information technology perspective, the key finding is partial digitalization: social media are used much more frequently than websites, business software or online payment. From the chamber perspective, the most useful finding is the possibility of segmenting members according to their needs, which enables more economical and precise education.

In practice, a chamber can act as an intermediary between the regulatory framework, educational institutions, IT experts and entrepreneurs. Education should be short, practical and sector-specific. For personal services, emphasis should be placed on appointment scheduling, client records and rules for communication on social media. For construction services, support should focus on offers, contracting and storage of client data. For trade and repair, the main topics should be invoices, service orders and customer data. For ICT and professional services, the focus should be on system security and processor responsibility.

### 5.1. Limitations of the research

Although the analysis is based on a survey sample, the results have several limitations. A sample of 150 responses does not necessarily represent all self-employed entrepreneurs in the Republic of Srpska and Bosnia and Herzegovina. Some variables are based on self-assessment, which may lead to the overestimation or underestimation of the actual level of knowledge. The study is cross-sectional and describes the situation in February 2026, without measuring changes after potential training activities.

## 6. PRACTICAL RECOMMENDATIONS AND IMPLEMENTATION MODEL

The empirical findings point to a practical need for a support model that is simple enough for micro and small entities, but still sufficiently comprehensive to cover both digital and legal aspects of business. The proposed model is not based on the assumption that all entrepreneurs

should immediately adopt advanced digital systems. Instead, it follows a gradual approach in which the first phase strengthens basic digital visibility, the second phase introduces safe data handling practices, and the third phase supports more advanced business software and electronic payments. This gradual model is suitable for chambers and local institutions because it can be implemented with limited resources and adapted to different sectors.

The first support module should focus on digital visibility and communication with clients. It should include practical training on the use of social media profiles, basic website presentation, digital catalogues of services, online appointment requests and standardized messages for client communication. For many craftspeople, this is the first contact with digitalization, and therefore the training should avoid abstract terminology. It should be based on examples from everyday practice, such as a hairdresser confirming appointments, a repair service receiving photographs of a defect, a small producer presenting products, or a construction entrepreneur sending an offer by e-mail. The expected result of this module is not only higher visibility, but also more consistent communication and reduced administrative burden.

The second support module should address personal data protection and legal certainty. Since 65.3% of respondents collect client data, while only 20.0% have a privacy policy or similar written notice, this is the most important compliance gap identified in the research. The chamber could prepare short model documents, including a one-page privacy notice, a basic consent form for specific cases, instructions for publishing photographs, and rules for storing client contact data. These documents should be written in plain language and accompanied by examples, because micro entities often do not have internal legal departments. The purpose is not to create excessive administration, but to build a minimum level of transparency, trust and accountability.

The third support module should be oriented toward business software, online payment and information security. Only 19.3% of respondents use online payment, while 44.0% use business software. This indicates that a significant part of the sector is still operating through fragmented records, informal communication and manual administrative procedures. In this module, entrepreneurs should be introduced to simple tools for invoicing, appointment management, service orders, stock records and secure cloud storage. At the same time, they should receive basic instructions on password management, access control, backups and the responsible use of client data in third-party applications.

The implementation model should also differentiate support by sector. Personal and other craft services require guidance on client appointments, photographs, health-sensitive information where applicable and communication through social networks. Construction and specialized works require templates for offers, contracts, documentation of completed work and the retention of client data. Trade and repair services require support related to invoices, service records, warranty communication and customer databases. Hospitality and food services need guidance on reservations, online reviews, photographs and digital promotion. ICT and professional services, although digitally more mature, require more advanced guidance on security, processor obligations and contractual responsibility.

From the perspective of public policy, the results suggest that digital transformation measures should be linked with local economic development instruments. Training, vouchers for digital tools, mentoring sessions and model legal documents can be combined into a single support package. A particularly important role can be played by chambers, because they have direct access to entrepreneurs and understand sector-specific barriers. Local development agencies and universities can provide methodological support, data analysis and evaluation of results. This cooperation would make it possible to monitor the impact of training and to update the support model according to measurable indicators.

For sustainability, the support model should include periodic measurement. The same DRI and GCI indicators can be used before and after training in order to assess whether entrepreneurs have adopted new tools and whether their data protection practices have improved. This would transform the chamber support system from one-time education into a continuous evidence-based service. The use of a standardized questionnaire, anonymized data and Python processing makes the method reproducible and suitable for repeated annual monitoring.

Finally, the psychological and organizational dimension of digitalization should not be neglected. Many micro entrepreneurs do not resist digital tools because they reject innovation, but because they face time pressure, uncertainty, fear of making legal mistakes and limited financial resources. Support measures should therefore be encouraging, practical and oriented toward immediate benefits. When entrepreneurs see that digital tools can save time, reduce errors and improve communication with clients, the willingness to adopt additional tools increases. At the same time, when legal obligations are explained through short and understandable templates, compliance becomes more realistic and less intimidating.

## 7. CONCLUSION

The paper shows that it is possible to develop a simple and reproducible methodological framework for assessing digital maturity and basic data protection compliance among craftspeople and self-employed entrepreneurs. The use of a Google Forms survey and Python processing provided sectoral insights, DRI and GCI indices, correlation values and segmentation of entities according to support needs.

It is recommended that the chamber, in cooperation with legal and IT experts, develop three support modules: (1) a basic module for digital promotion and client communication; (2) a legal compliance and data protection module; and (3) an advanced module for digital business, software, online payments and transaction security. Short sectoral guides should be prepared

for personal services, construction crafts, hospitality, production crafts, trade and repair, and ICT/professional services.

Future research should expand the sample, include longitudinal measurement before and after training and conduct qualitative interviews with entrepreneurs. This would make it possible to determine more precisely which barriers most strongly affect slow digitalization: tool cost, lack of knowledge, mistrust of online payment, legal uncertainty or lack of time.

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## APPLICATION OF THE THREE LINES OF DEFENSE MODEL IN INTERNAL AUDIT IN BIH

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### Abstract

*The Three Lines of Defense Model represents one of the most important contemporary frameworks for risk management, internal controls and corporate governance. Developed by the Institute of Internal Auditors (IIA), the model was first formalized in 2013 and then significantly improved in 2020 to respond to the growing complexity of the business environment and the need for an integrated approach to value management (IIA, 2020).*

*The fundamental purpose of the model is to clearly define responsibilities and relationships between key functions within an organization. The model distinguishes three basic lines: the first line (operational management), the second line (supervision and support functions) and the third line (internal audit). Each of these lines has a specific role, but their effectiveness depends on mutual cooperation, communication and coordination. The first line is responsible for risk management and the implementation of controls in everyday business operations. The second line supports, monitors and oversees the effectiveness of controls, while the third line – internal audit – provides independent and objective assurance on the functioning of the entire system. The updated 2020 model emphasizes the transition from a “defensive” approach to the concept of creating and preserving value.*

*In conclusion, the three lines of defense model represents an integrated framework that connects management, control and audit into a single system. Its value lies in its clear accountability structure, but also in its ability to adapt to different organizational and institutional contexts.*



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# 1. INTRODUCTION

In the modern business environment characterized by globalization, digitalization and increased regulatory requirements, organizations are faced with a growing need for effective risk management and controls. Traditional approaches to supervision and control are no longer sufficient to deal with the complex challenges arising from dynamic market conditions and increasing stakeholder expectations. In this context, the Three Lines of Defense Model has developed as a key concept of corporate governance that enables clear definition of responsibilities, transparency and effective monitoring of organizational processes. The Institute of Internal Auditors (IIA) recognized the need for a standardized framework and presented a model in 2013 that was further improved in 2020 (IIA, 2020).

The three lines of defense model is based on the idea that different functions within an organization have different but complementary roles in risk management. Operational management is responsible for day-to-day management and control, the supervisory functions provide support and monitoring, while internal audit provides an independent assessment of the system's effectiveness. The importance of this model is particularly evident in the public sector, where transparency and accountability are key prerequisites for the effective management of public resources. In Bosnia and Herzegovina, the model is integrated into the financial management and control system (FMC), thus becoming the basis for institutional oversight and control.

The aim of this paper is to analyze the development, structure and application of the three lines of defense model, with special emphasis on its role in improving the management and control system. Special attention is paid to the role of internal audit as a key element of the system, as well as the challenges of implementing the model in practice. The development of the three lines of defense model is closely related to the development of internal audit and the concept of risk management. The roots of internal audit date back to early civilizations, but its modern

form developed at the beginning of the 20th century with the emergence of large corporations.

The three lines model helps organizations achieve their goals through effective risk management, transparency and accountability. It distinguishes three levels of roles:

1. Operational management – risk owners,
2. Oversight and compliance functions – support and verification,
3. Internal audit – independent and objective assurance.

In Bosnia and Herzegovina, the model is becoming an important tool within the public sector, especially in the context of financial management and control (FMC), which further highlights its importance for transparency and efficiency

The concept of the Three Lines of Defense was first systematically presented by the IIA in 2013, in response to the need for a clear framework of responsibilities in risk management.

In practice, it has been shown that many organizations have multiple levels of oversight and control, but without clearly defined relationships between them, which often led to ambiguities and overlaps.

In 2020, the IIA published an updated document, The Three Lines of Defense Model, which replaces the previous name “three lines of defense” with a more modern approach that emphasizes value creation and preservation (IIA, 2020). This new model does not see risk management as just a defense mechanism, but as an integrated process of creating added value for the organization's stakeholders.

## 2. REASONS FOR MODERNIZING THE MODEL

The updated model introduces several key changes:

Instead of linear defense, the emphasis is on collaboration and interconnection of lines,

The governing body now has a more clearly defined accountability to stakeholders,

Internal audit acts as an advisor and partner in improving the business,

There is an increased focus on strategic risk management and integrity.

The Three Line Model is based on six principles defined by IIA Global (IIA, 2020):

1. Governance – the organization must have structures and processes that enable accountability, integrity and transparency.
2. The role of the governing body – oversees the organization, sets the risk appetite and directs resources.
3. The role of management (first and second lines) – manages operations and risks.
4. The role of internal audit (third line) – provides independent and objective assurance.
5. Third line independence – essential for the credibility and authority of the audit.
6. Creating and preserving value – all lines together contribute to the creation and protection of organizational value.

These principles do not divide lines strictly hierarchically, but functionally. A successful organization achieves synergy through communication and cooperation between all lines.

Model structure:

#### a) First line – Operational management

The first line consists of employees and managers who directly manage business processes and risks. They are the “risk owners”.

Their responsibilities include:

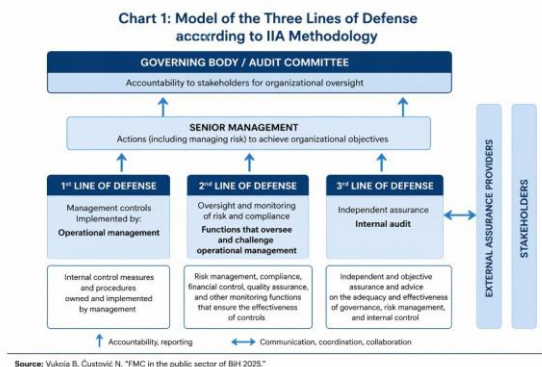
- implementing controls and procedures,
- identifying and mitigating risks,
- ensuring that activities contribute to the organization’s goals.

In practice, the first line

In practice, the first line is the foundation of an effective control system – without it, the other lines cannot function successfully.

The following diagram (IIA, 2020) shows the relationships between roles:

*Chart 1: Model of three lines of defense according to the IIA methodology*



*Source: Vukoja B, Čustović N. "FMC in the public sector of BiH 2025."*

#### b) Second line – Support and oversight functions

The second line includes functions that help monitor and support the first line.

These are most often: risk management, compliance, internal control, security and quality control departments. Their task is to ensure that risks are identified and that the control system is working according to plan.

#### c) Third line – Internal audit

Internal audit operates independently of management and reports directly to the management body or audit committee.

It provides objective assurance that the management and control system is functioning effectively.

In addition to the audit role, internal audit also provides advisory services that help management improve business processes and risk management.

At the top of the system is the management body – the supervisory or audit committee.

Its task is to ensure the independence of internal audit, approve its plans and monitor the implementation of recommendations.

The three lines of defense model today represents a globally accepted framework for corporate governance and risk management. Its value stems from the clarity of roles and responsibilities and the built-in cooperation mechanisms between management and internal audit.

In the context of the BiH public sector, the model of three lines of defense has additional importance because it contributes to transparency, accountability and efficiency in the management of public resources.

The updated model defines six principles that make up its theoretical basis:

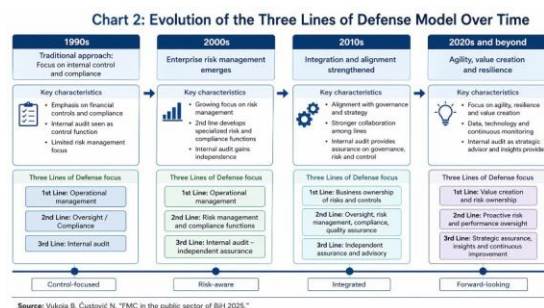
- Management - ensuring accountability and transparency.
- The role of the governing body - supervision and delegation of resources.
- Role of management (first and second line) – implementation of activities and risk management.
- Role of internal audit - independent assurance and advisory function.
- Independence of the third line – crucial for credibility.
- Creation and preservation of value - synergistic action of all lines.

Unlike the previous version, the new model no longer views the three lines as strictly separate segments, but as interconnected functional roles. The purpose of the model is not only to "defend against risks", but also to optimize resource management and improve the decision-making process

The model also contributes to the development of the concept of "governance assurance" - a combined approach to internal control, risk management and internal audit, which reduces duplication and increases efficiency. The development of the three lines of defense model shows a clear shift from traditional auditing to an integrated corporate governance system. The model is not only a control tool, but also a concept of value management.

Its importance is particularly evident in public institutions, where a clear demarcation of responsibilities between management, control functions and internal audit is a prerequisite for transparent and efficient use of public funds.

*Chart 2: Evolution of the three lines of defense model over time*



*Source: Vukoja B, Ćustović N. " FMC in the public sector of BiH 2025."*

The theoretical strength of the three lines of defense model lies in its ability to integrate multiple control systems into a single structure. It connects operational operations, control functions and audit into a coherent system that:

- strengthens management accountability,
- enables early identification of risks,
- and establishes self-assessment and correction mechanisms.

### 3. PRINCIPLES OF THE THREE-LINE MODEL

The three-line model is based on six fundamental principles that define the relationships between key participants in the management and control system. These principles are not just technical elements of the model, but a management philosophy that fosters a culture of integrity, collaboration, and accountability throughout the organization (IIA, 2020).

According to the IIA, the six principles of the three-line model are:

- Governance,
- The role of the governing body,

- c) The role of management (first and second lines),
- d) The role of internal audit (third line),
- e) Independence and objectivity of the third line,
- f) Creating and preserving value.

#### a) Principle 1 – Governance

Governance is the basic framework within which all three lines operate. It encompasses policies, processes, and structures that enable the effective achievement of the organization's objectives and ensure oversight of risks.

The governance framework of an organization must include:

- A clear division of responsibilities between operational management, oversight functions and audit,
- Integrity and transparency in decision-making,
- Compliance with regulatory, legal and ethical standards.

According to OECD (2015), good governance is based on accountability, predictability and the rule of law.

In this sense, the three-line model lays the foundation for integrated corporate governance that enables oversight and control without duplication of responsibility.

#### b) Principle 2 – Role of the governing body

The governing body has ultimate accountability to stakeholders and the public. Its role in the three-line model is particularly emphasized in the 2020 version, where it is seen as a central element of the governance system.

The governing body:

- approves the organization's strategy and policies,
- defines the risk appetite and framework for acceptable behavior,
- appoints and oversees the internal audit,
- ensures that management effectively manages risks and controls.

According to IIA (2020), the governing body must actively monitor all three lines, but without operational interference in their work. This ensures a balance between supervision and operational autonomy of management.

#### c) Principle 3 – The role of management (first and second line)

Management has a key role in the functioning of the model because it represents the operational core of the organization.

The role of management within the first and second lines is defined through:

*Table 1: Role of management*

| Line        | Primary function                 | Primary goal                   | Examples of activities                                                            |
|-------------|----------------------------------|--------------------------------|-----------------------------------------------------------------------------------|
| First line  | Operational management           | Delivery of goals and products | Risk identification, implementation of controls, daily monitoring                 |
| Second line | Monitoring and support functions | Risk management support        | Risk management support Compliance, quality control, IT security, risk management |

*Source: Vukoja B, Ćustović N. FMC in the public sector of BiH 2025.*

First line Operational management Delivery of goals and products Risk identification, implementation of controls, daily monitoring

Second line Monitoring and support functions Risk management support Compliance, quality control, IT security, risk management

Management ensures that the organization operates in accordance with the set standards and policies and that risks are within an acceptable appetite.

In practice, managers represent the “first line of defense” because they are the first to react to risks that may affect the organization's objectives.

#### d) Principle 4 – The role of the third line: internal audit

The third line in the model has a unique and independent role. Internal audit provides objective assurance on the effectiveness of the management and control system and advises the board and management on opportunities for improvement (IIA, 2020).

According to the international definition of the IIA (2001):

“Internal audit is an independent and objective function that provides assurance and consulting services with the aim of adding value and improving the organization’s operations.”

Internal audit must operate independently of management, but must also maintain constant communication and cooperation with it.

The role of internal audit can be viewed through three dimensions:

- a) Assurance function – assesses the effectiveness of controls and risk management,
- b) Advisory function – provides recommendations and helps improve processes,
- c) Preventive function – helps prevent fraud and irregularities.
- e) Principle 5 – Third-line independence and objectivity

Independence is a fundamental assumption of the credibility of internal audit.

IIA Standard 1100 stipulates that internal audit must be organizationally independent, which means that auditors must not have operational responsibilities in the areas they audit.

Independence is ensured through:

A direct reporting line to the governing body or audit committee,

Functional and administrative autonomy of the audit function,

Protection from management influence on the content of reports and planning of activities.

Objectivity implies a professional attitude of the auditor that enables impartiality and fair judgment.

IIA (2020) emphasizes that independence does not mean isolation – audit must be involved in communication and coordination with other lines, while maintaining professional integrity.

#### f) Principle 6 – Creating and preserving value

The sixth principle represents the crown of the three-line model.

The goal of all lines is not only to defend against risks, but to actively participate in creating and preserving value for stakeholders.

Each line contributes in its own way:

*Table 2: Contribution of lines to creating value*

| Line        | Key contribution to creating value                                         |
|-------------|----------------------------------------------------------------------------|
| First line  | Second line Establishing a control system and monitoring risks             |
| Second line | Second line Establishing a control system and monitoring risks             |
| Third line  | Independent assurance, consulting and contribution to business improvement |

*Source: Vukoja B, Ćustović N. “ FMC in the public sector of BiH 2025.*

According to the updated model (IIA, 2020), the synergy between lines results in a sustainable business model that maximizes value, reduces risks and strengthens the trust of the public and stakeholders.

#### Mechanisms of cooperation between lines

Cooperation and communication between lines are key prerequisites for the successful application of the model.

In practice, this includes:

- Regular coordination meetings between management and internal audit,
- Exchange of information on risks and control findings,

- Establishment of assurance maps that show the sources of assurance within the organization. Critical review of the application of the principles in practice.

In practice, the application of the principles of the model faces several challenges:

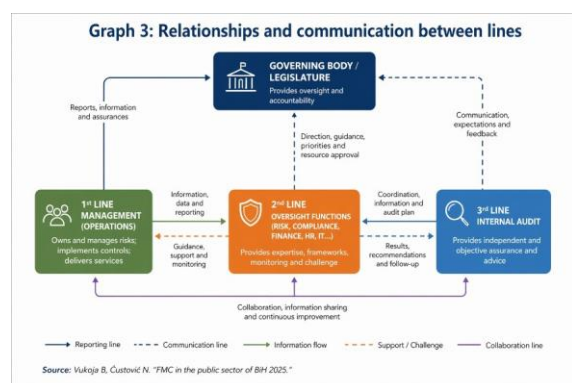
Unclearly delineated responsibilities between the second and third lines,

Limited internal audit resources in public institutions,

Insufficient education about the model among management,

The need to strengthen the culture of accountability and ethics.

Graph 3: Relationships and communication between lines]



Source: Vukoja B, Ćustović N. "FMC in the public sector of BiH 2025."

However, IIA (2021) research shows that organizations that have consistently implemented the principles of the model record significantly higher risk management effectiveness and a higher level of stakeholder trust.

The six principles of the three lines of defense model form an integrated framework that enables balanced, transparent and effective management of the organization.

Each principle contributes to building a system that not only protects, but also improves business.

The application of these principles is key to the successful implementation of the model in practice, especially in public institutions and special interest companies.

## 4. APPLICATION OF THE THREE LINES OF DEFENSE MODEL IN PRACTICE

The application of the three lines of defense model in practice is a key test of its effectiveness.

While the theoretical framework clearly defines the roles and principles, the actual The implementation of the model in organizations depends on:

- the size and complexity of the organization,
- corporate culture,
- regulatory requirements,
- and the level of maturity of the management and audit functions.

Main benefits of implementing the model in BiH

The implementation of the three-line model in the FMC system brings a number of benefits to public sector institutions:

- Clear demarcation of responsibilities among employees,
- Increased transparency in the use of public funds,
- More effective detection of irregularities and fraud,
- Better cooperation between ministries and supervisory bodies,
- Strengthening public trust in institutions.

The Ministry of Finance of BiH (2022) states that institutions that have established the FMC model have recorded an increase in supervision efficiency by more than 30% and a reduction in irregularities in the spending of funds.

Limitations and challenges in BiH practice

Despite progress, BiH faces certain challenges in implementing the model:

- lack of educated internal auditors,
- fragmented application of the model in different institutions,
- lack of coordination between levels of government,

- insufficient digitalization of the supervision process.

According to the PEM-PAL report (2021), BiH is in the “middle maturity phase” in terms of model implementation.

Further progress requires centralized coordination and continuous employee education.

Key performance indicators of the model in practice

A number of key performance indicators (KPIs) are used to monitor the effectiveness of the three-line model.

The most commonly used indicators include:

- number of irregularities detected in audit reports,
- management response time to recommendations,
- percentage of internal audit recommendations implemented,
- number of risk management training sessions,
- degree of digitalization of the reporting process.

According to a study by IIA Europe (2022), organizations that use KPI systems to monitor the work of the three lines record a 20–40% higher level of risk management efficiency.

## CONCLUSION

Today, the three lines of defense model represents a fundamental framework for effective management of organizations in a modern business environment. Its application enables a clear definition of responsibilities, strengthening of the risk management system, and increasing transparency and accountability to stakeholders.

The analysis shows that the greatest value of the model lies in its integrative function – connecting operational management, control functions, and internal audit into a single system. This synergy enables organizations to not only manage risks, but also actively create value.

The role of internal audit is particularly important, as the third line provides independent assurance and contributes to the improvement of business processes. However, its effectiveness depends on

the independence, expertise, and support of the governing body.

In the context of Bosnia and Herzegovina, the model plays a key role within the FMC system, where it contributes to transparency and responsible management of public funds. However, its full implementation requires additional efforts in education, digitalization, and strengthening of institutional capacities.

Despite the challenges, the three lines of defense model remains the most accepted international standard for risk management and controls. Its future lies in adapting to new technologies, digitalization, and integration of ESG principles.

In conclusion, the three lines of defense model is not only a control tool, but a strategic framework for managing organizational value and long-term sustainability.

and based on theoretical and practical analysis, it can be concluded that the Three Lines of Defense Model represents the basic architecture of the responsibility system in contemporary organizations.

Its strength lies in integration – each line has its role, but only their synergy brings real results.

In the context of Bosnia and Herzegovina and the wider region, the three-line model should become a standard of management and control in the public sector, not just a recommendation.

Its implementation is not a goal, but a process of continuous improvement.

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# THE INFLUENCE OF PHYSICO-CHEMICAL AND ENVIRONMENTAL FACTORS ON THE EXPLOSIBILITY OF COAL DUST AND PREVENTION MEASURES

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coal dust, explosion,  
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## Abstract

*The explosiveness of coal dust is a complex process determined by the action of physicochemical and environmental factors. Among the most important physical factors are the particle size distribution and dust concentration in the air, where finer particles and an optimal concentration significantly increase the risk of explosion. The chemical composition, especially the content of volatile matter, directly affects flammability and combustion intensity, while the presence of inert substances reduces explosiveness by absorbing heat.*

*Environmental factors, such as the presence of methane, oxygen content, temperature, pressure, and ventilation, play a key role in the initiation and propagation of an explosion. Methane is particularly dangerous because it can act as an initial trigger of an explosion. Moisture in dust generally reduces explosiveness, but under certain conditions it may contribute to its intensity.*

*Preventive measures include controlling the concentration of dust and gases, effective ventilation, the use of inert dust, maintaining optimal humidity, and eliminating ignition sources. Through systematic implementation of these measures, it is possible to significantly reduce the risk and consequences of explosions in mines.*



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# 1. INTRODUCTION

A coal dust explosion means the rapid burning of a cloud of coal dust in the air in a confined or partially confined space. A coal dust explosion is accompanied by the release of a large amount of heat, a sudden increase in the volume of gases and the development of high pressures.

The coal dust ignition explosion process can be divided into three parts:

ignition of coal dust,

coal dust explosion process, i.e. its development and

phenomena accompanying the explosion of coal dust.

## 2. COAL DUST EXPLOSION AND INFLUENTIAL FACTORS

### 2.1. Coal dust ignition

For the ignition of coal dust, the main role is played by the separation and ignition of volatile constituents. Volatile substances are released from the coal particles under the thermal effect of the coal dust cloud explosion.

The mixture of volatile substances with air is explosive and easily flammable. By burning volatile substances, the flame is transferred to smaller and then to larger particles of coal dust [4].

The amount of volatile substances released from coal dust, as well as the burning time, depends on the degree of pulverization of the coal dust. It has been scientifically proven that dust, with a grain size of up to 0.5 mm, participates in the explosion.

Depending on the type of coal dust and the conditions of the explosion, the quantities of gas products of the explosion are different.

Analysis of a large number of gas composition samples after a coal dust explosion determined the following situation:

maximum carbon monoxide content of up to 10,8 %;

carbon dioxide content up to a maximum of 15,0 %;

maximum hydrogen content up to 3,7 %;

minimum oxygen content 0,1 % [5].

### 2.2. Coal dust explosion transmission

In the explosion zone, the air density is higher than in the air that is not included in the explosion. During a coal dust explosion, static pressures occur. Pressure in a coal dust explosion plays one of the main roles both at the beginning of the explosion and during its course. In a coal dust explosion, the pressure increase is related to the speed of the shock wave. Shock wave velocity, pressure rise and temperature, are directly proportional values.

By moving through the pit room, the shock wave raises (swirls) the deposited coal dust, partially moves it in the direction of the explosion flow and thus causes more dust in the explosion zone.

The pressure developed by the cause (initial) of the explosion must be at least 1 kN/m<sup>2</sup> (0,01 bar) in order for the deposited coal dust in the vicinity of the initial explosion to swirl and create a cloud of sufficient concentration for the explosion. Such a low pressure can only swirl fine and dry dust with convenient distribution in the mining room.

An increase in pressure in an environment increases the temperature. In the case of a coal dust explosion, the increase in pressure is related to the speed of the shock wave.

Under conditions of normal atmospheric pressure, coal dust is not capable of explosion.

### 2.3. Phenomena accompanying the explosion of coal dust

During the explosion, the flame front, which moves through the mining room, is preceded by a shock wave that causes an increase in the heat of the gas environment. The total heat of the explosion depends on the speed of the shock wave, and the speed of the shock wave depends on the speed of the flame. The total heat of the coal dust explosion represents the sum of the heat of combustion from separated volatiles (about 22

% of the total volatiles burn), the heat of combustion of coal dust (about 20% of the total dust present burns) and the heat generated due to the increase in the density of the environment [1].

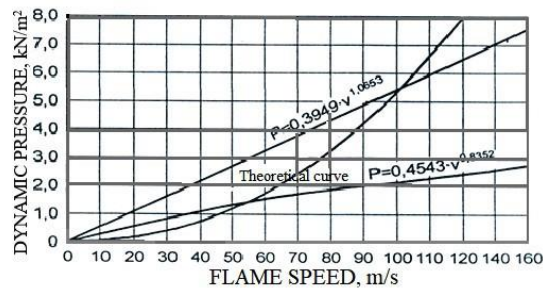


Figure 1. Dependence of dynamic pressure on flame speed of very weak coal dust explosions - Source 1

A coal dust explosion can be divided into three characteristic phases:

The first phase of the explosion is characterized by the fact that the explosion is initiated in one place. A coal dust explosion is most often initiated by ignition or explosion of methane or by unprofessional use of explosives [5].

In the second phase of the coal dust explosion, the flame covers the entire profile of the mining room.

The third phase of a coal dust explosion is the phase in which the explosion is the strongest and when the explosion can turn into detonation. In this phase, the speed of the flame and the shock wave are the same and can reach 2000 m/s.

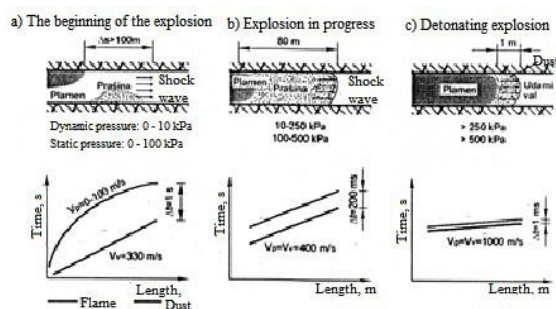


Figure 2. Elements of coal dust explosion flow

## 2.4. Conditions for explosion of coal dust

In order for a coal dust explosion to occur, the following conditions must be met:

there must be a sufficient amount of explosive coal dust,

coal dust must be dispersed in the air, must be stirred up,

air mixed with dust must have sufficient oxygen content and

there must be a strong enough initial to initiate the coal dust explosion process.

All four mentioned conditions must occur at the same time, which at first glance may lead to the conclusion that coal dust explosion is unlikely to occur.

However, practice has shown that coal dust explosions can easily occur. If there is a concentration of explosive coal dust in the mining room above the lower explosive limit, it is enough to cause a local explosion of methane or blasting with open stick mines, which could result in an explosion of coal dust [1].

The methane explosion will swirl up the deposited coal dust and its heat energy transfer to the surface and thus start the explosion of coal dust. This assumption does not mention the condition of sufficient oxygen content. It is only a theoretical and formal assumption because it is known that in all active mining premises there must be good quality pit air.

## 2.5. The influence of the chemical composition of coal dust

An explosion of coal dust can occur if its concentration is between the lower and upper explosive limits.

The strength of the explosion, among other things, also depends on the amount of coal dust in the explosive mixture with air. The strongest explosion occurs at a concentration of 111,4 g/m<sup>3</sup> of dust, provided that all the dust is burned. Since only up to 20 % of dust participates in the explosion, the stoichiometric concentration of dust increases several times and ranges around 500 g/m<sup>3</sup>.

It has been proven that volatiles, with their presence, play the biggest, perhaps even decisive, role in the creation of an explosion.

In the coal dust explosion process, the volatiles, which are separated from the coal dust under the

influence of high temperature, are the first to take over the burning.

After the volatiles, chemical substances (resins) are burned, which are separated from the dust through the pyrolysis process. After the volatiles and resin, first the finer and then the larger fractions of dust are burned.

The participation of individual gas components in the volatiles is different, and to the greatest extent depends on the type of coal dust, physical and chemical properties and conditions that cause the release of volatiles.

Based on the aforementioned facts, regulations were adopted according to which coal dust containing less than 14 % of volatiles is considered explosively harmless [5].

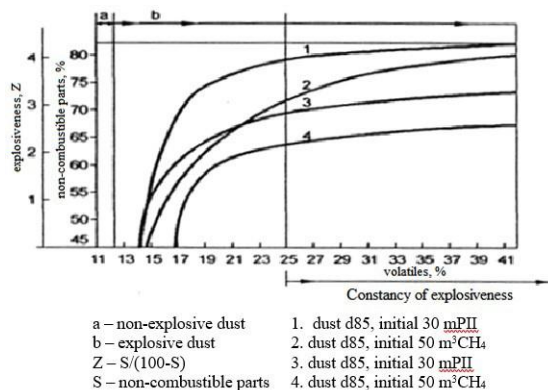


Figure 3. Dependence of coal dust explosion (z) on volatile content (V)

If coal dust contains more than 14% volatile dust, it is considered explosively dangerous, so according to the Regulations, further tests of other explosive characteristics must be carried out.

The percentage content of volatiles in coal dust depends on the age of the coal, that is, on the degree of carbonization. In younger coals with a lower degree of carbonation and lower caloric values, the content of volatiles is higher and vice versa. From these facts it follows that the coal dust of younger coals of Pliocene and Oligomiocene age is more explosive from the point of view of the influence of volatiles.

## 2.6. Effect of moisture in coal dust

The presence of moisture in coal dust reduces its explosiveness. The moisture content affects the

reduction of the heat balance of the system, in addition, it supports the coagulation of small particles. As a result, the particles stick together, that is, the formation of larger dust [1].

If the air contains a large amount of moisture, the accumulated dust absorbs it. Moist coal dust is more difficult to swirl, which makes it difficult to create dust clouds.

In addition, it is more difficult to ignite, since it needs to dry first, and for that a certain amount of heat and time is needed. According to the orientation data, the average values of the moisture content in the dust of our coals of different ages are as follows:

coal dust contains 1 to 3 % moisture, brown

coal dust contains 4 to 5 % moisture,

lignite coal dust contains 10 to 25 % moisture [1].

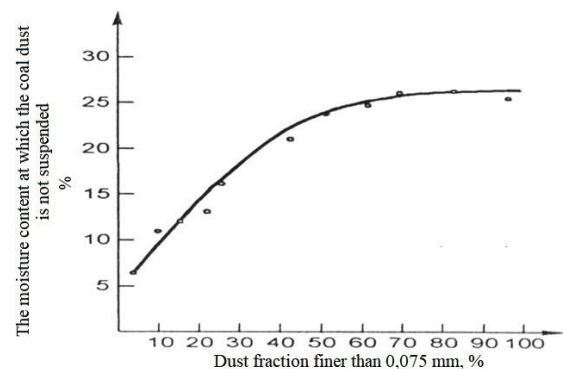


Figure 4. Coal dust buoyancy indicator depending on the content of the granulometric composition of the dust

It has been proven that dust with a higher moisture content can participate in an explosion and that such explosions are more powerful than an explosion with dry coal dust.

This phenomenon is explained by the fact that moisture in coal dust under the influence of high temperature creates highly explosive H<sub>2</sub> and CO gases that accelerate the explosion.

## 2.7. The influence of the content of solid non-combustible particles in coal dust

The presence of solid non-combustible particles in coal dust reduces its explosiveness. The action of solid particles in preventing an explosion is based on the removal of heat, and their presence

in the explosive environment shields the particles of coal dust from the heat of the radiation of the initials of the explosion [7].

For this reason, rock dust has found wide application as a means of preventing coal dust explosions. Stone dust was widely used in the construction of dams to prevent the transfer of coal dust explosions. Dust is considered non-explosive if its composition contains 70% of solid non-combustible particles in non-methane pits, or 80 % in methane pits [7].

## 2.8. The influence of the granulometric composition of dust

The fineness of coal dust is indicated by the specific surface area ( $\text{cm}^2/\text{g}$ ). In order to determine as accurately as possible the amount of fine - very fine coal dust, which has a great impact in the explosion process, an international unit was adopted that indicates the percentage of the dust fraction with a grain diameter smaller than 0,075 mm.

This value is denoted, for example, by d30, which means that in the coal dust sample there is 30% fraction smaller than 0,075 mm. Coal dust with a higher percentage of finer dust is more explosive than larger dust.

This is explained by the fact that finer dust has a larger specific surface area, and as such it separates volatiles to a greater extent in the phase of thermal action on the surface. For the same reasons, there is also the fact that the ignition of finer coal dust requires a weaker initial explosion.

Another disadvantage of finer dust is that it is more difficult to bond with moisture, i.e. more difficult to coagulate.

## 2.9. Effect of methane content

Methane, as the most common explosive gas in coal deposits, was created with the carbonization process of the deposit. With the increase in carbonization of coal, the content of volatiles decreases, and the content of methane increases. The presence of explosive gases in the explosive mixture of coal dust and air increases the explosiveness. In the largest cases of coal dust explosions, inflammation or methane explosion.

When the methane content in the pit air is less than the lower explosive limit ( $<4,5\% \text{ CH}_4$ ) of methane, its presence helps in the transmission of coal dust explosion.

If the methane content in pit air is below the stoichiometric mixture ( $<9,5\% \text{ CH}_4$ ), then methane increases the explosiveness of coal dust. With the increase in methane content above 9,5 % and up to the upper explosive limit of 14 %, the presence of methane continues to increase the explosiveness of coal dust, but with a decreasing effect.

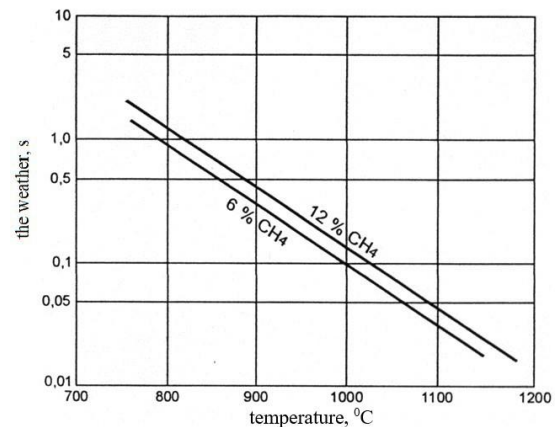


Figure 5. Dependence of methane ignition delay on initial temperature

## 2.10. The effect of coal dust ignition initials

The most common coal dust explosion initials are:  
 improper use of explosives,  
 methane explosion,  
 short circuit electric arc i  
 open flame.

The ignition temperature of deposited coal dust is always lower than the explosion temperature of coal dust. This is explained by the fact that the particles of deposited dust are very close to each other, so the transfer of heat from particle to particle is lossless. The burning rate of settled coal dust has less contact with air compared to suspended coal dust.

With the increase in the strength of the initial explosion, the lower limit of the explosiveness of coal dust decreases, the buoyancy of dust increases, the pressure in the explosion zone

increases and thus the temperature of the environment, which also increases the explosiveness of coal dust. When the dust cloud comes into contact with the ignition source, which has a temperature of 300 to 400 °C, individual finer dust particles are ignited. When the initial temperature increases to 500 to 700 °C, the dust ignites with the appearance of a flame that quickly goes out, and when the temperature increases to 700 to 800 °C, the flame spreads throughout the cloud and an explosion occurs.

From the above, in some literature you can find different data for sparking, ignition and explosion temperatures of coal dust. These sizes are not constant and depend on the type of dust, degree of dispersion and other characteristics.

### **3. WORKING ENVIRONMENT OF EXAMINATION OF INFLUENTIAL FACTORS**

The research on the explosiveness of dust as a function of the content of inert matter and particle size was carried out on coals of Miocene age from the central Bosnian coal basin.

The main coal seam was selected for research. The selection of the main coal layer for research was made due to the intensity of mining operations in this layer, continuous development and economic interest (the most interesting for exploitation).

### **4. PREVENTIVE MEASURES FOR COAL DUST EXPLOSION PREVENTION**

Mine safety represents one of the most critical aspects of mining production. Given the high hazard of coal dust explosions, numerous preventive measures have been developed to reduce risk and protect both workers and equipment [8].

One of the fundamental measures is the regular removal and control of dust deposits. Dust must be removed from surfaces or neutralized (bound) to prevent it from becoming airborne and forming an explosive mixture.

Dust wetting (spraying) is also a highly effective method. Adding water reduces the dispersibility of particles and their flammability. This method is frequently used in combination with ventilation [3].

Ventilation systems play a key role in maintaining safety. Proper ventilation reduces the concentration of dust and methane in mine workings, thereby directly decreasing the possibility of an explosion.

The application of inert (stone) dust is one of the most important protective measures. This dust is spread throughout the mine galleries to reduce the concentration of combustible coal dust and prevent the propagation of flames.

The control of ignition sources also plays a vital role. This includes:

Proper use of explosives

Use of intrinsically safe electrical equipment

Prohibition of open flames

Regular maintenance of installations

In addition, continuous monitoring of methane and dust concentrations using modern measuring devices is essential. In the event of elevated values, work must be suspended immediately.

Worker education and the implementation of safety procedures are also of crucial importance. Trained workers can recognize hazards in a timely manner and prevent the occurrence of an accident.

### **CONCLUSION**

Evo prevoda vašeg teksta na engleski jezik, uz primjenu standardne naučne terminologije koja se koristi u rudarstvu i istraživanju eksplozivnosti:

Translation

Results of multi-year research on the explosive characteristics of coal samples and deposited brown coal dust from the main seam of the Central Bosnian Basin (Kakanj, Breza, Zenica), conducted under laboratory conditions, were used to determine the correlation between explosiveness, inert matter content, and particle size.

According to the explosiveness assessment parameter - the maximum rate of pressure rise - the dust from this coal seam falls into the category of highly explosive dust [2].

The study examined the influence of moisture, ash, volatile matter, and particle size distribution (median size and the content of particles smaller than 75  $\mu\text{m}$ ) on dust explosiveness.

The investigation into the effect of moisture on coal dust explosiveness was performed on dust prepared from the coal seam with a precisely defined particle size distribution and constant ash and volatile matter values. It was established that dust with lower moisture content is more explosive than dust with higher moisture content. The presence of moisture in coal dust reduces explosiveness; specifically, as moisture content increases, explosiveness decreases, and vice versa. Consequently, the risk of a coal dust explosion is greater during prolonged production halts, as the deposited dust dries out.

The investigation into the effect of ash on coal dust explosiveness was conducted on dust prepared from the coal seam with a precisely defined particle size distribution and constant moisture and volatile matter values. It was determined that dust with lower ash content is more explosive than dust with higher ash content, indicating that the presence of ash has a positive effect on reducing coal dust explosiveness. This fact necessitates the application of inert dust as a measure for preventing and localizing coal dust explosions in mines. The study of the dependence of explosive characteristics on the percentage of volatile matter showed a low regression coefficient, meaning their influence can be considered constant.

Dust explosiveness in relation to particle size distribution was tested on dust prepared from the coal seam, while moisture, ash, and volatile matter were kept constant. It was found that dust with a smaller median (finer particles) is more explosive than dust with a larger median, and that explosiveness increases with the rise in the proportion of particles smaller than 75  $\mu\text{m}$ .

From the perspective of occupational health and safety, the research results highlight the need for

the consistent application of preventive measures to reduce the risk of coal dust explosions in mining areas. Particular importance is placed on the control of moisture, particle size distribution, the use of inert materials, as well as the regular maintenance and cleaning of working areas.

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## CONSULAR FUNCTION IN THE CONTEXT OF THE VIENNA CONVENTION

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### Abstract

*The paper contains a comprehensive overview of the essential determinants of consular law, consular functions, as well as an analysis of administrative law elements used during the performance of consular duties. It is stated that there are certain problems in the application of the law of the receiving state, which the sending state is obliged to respect. The principles and norms of administrative law and administrative procedure of the receiving state are difficult to apply in their entirety due to the need for speed of procedure, especially where the exercise of certain property or status rights of citizens of the sending state is at stake. In this regard, the paper states that according to the Vienna Convention on Consular Relations of 1963, there are certain diplomatic and political competences and functions of consular duties, while a part of the functions relate to purely formal-legal functions. The paper approaches the analysis of benefits, privileges and immunities in a completely new way, with the conclusion that the degree of privileges for persons performing consular duties is really high, that they to a certain extent help to perform consular duties both economically and efficiently, but also that in certain cases they violate the criteria of rights and freedoms that the receiving citizens have, and that there are privileges that can be turned into abuse. As one of the possible points of abuse, the paper accepts the possibly unconstitutional and illegal actions of the sender, with the aim of disrupting the stability of the recipient state. Despite this, the conclusion of the work is that consular law should be developed in the context of the intentions set by international conventions on consular relations and affairs.*



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## 1. INTRODUCTION

Although there have been numerous elements of the development of diplomatic missions throughout history, it can be said that the structure and functions of diplomatic or consular functions are relatively permanent and have not been fundamentally changed or modified much. The mid-20th century was of crucial importance for the functions of diplomacy and consular affairs, when a certain codification of customary norms occurred and diplomatic law was conditionally established as an integral part of international public law. During that period, from 1961 to 1975, conventions were adopted and entered into force that legally shaped the previous practice and needs of diplomatic affairs in the global context (Dašić, 2013). What is particularly important is that the adoption of conventions regulating diplomatic relations and diplomatic activity also regulated consular affairs in a more concrete way, in a way that specified and partially determined the manner and conditions for their implementation. On the other hand, it is a kind of unification of administrative procedures by which certain documents are obtained or certain rights are exercised on that basis. That is why the conventions helped administrative procedures because until then, a special administrative procedure was conducted in the work of consular bodies that did not have legal sources, so according to a principle of subsidiarity, the norms of general administrative procedure were applied, which are acceptable from a general theoretical point of view, but which in some types of procedures, with regard to procedures and deadlines, greatly slow down the processes of adopting administrative acts and undertaking administrative actions for diplomatic bodies. During the history of diplomatic relations and consular relations and affairs, and especially during the 20th century, diplomatic and consular law developed as newer branches of law. It also defined its subject of study and they were defined as concepts. Diplomatic and consular law is understood as a set of all provisions of international law that relate to the rights and duties of states in relation to diplomatic relations,

functions, privileges and immunities of diplomatic missions and diplomatic staff, as well as other members of diplomatic missions (Pašić, 2008). From such a definition of the term diplomatic and consular law, one can understand the international community's effort to regulate relations, situations and processes established between states in international legal relations with general norms and to regulate these issues in a more concrete, codified and unified way with legal norms. For this reason, especially in the last century, a series of bilateral and multilateral treaties and eventually conventions on diplomatic and consular relations were adopted. This was facilitated by the rapid progress of civilization and IT technology, especially the need to ensure a greater flow of people, goods and capital. It is important to note that the character of consular affairs is determined by the very meaning of the term diplomatic and consular relations. In this sense, diplomatic relations mean official relations between states. The establishment of diplomatic relations should be distinguished from the establishment of diplomatic missions in states with which diplomatic relations exist, because diplomatic relations can exist even if permanent diplomatic missions have not been established between the states in question. The establishment of diplomatic relations requires the mutual consent of the respective states, as well as the establishment of their permanent diplomatic missions, as stipulated in Article 2 of the Vienna Convention on Diplomatic Relations (Pičuljan, 1999). In addition to the aforementioned legal prerequisites for the functioning of consular offices, or for the performance of consular duties, there are other legal acts that are a material source of law. These are regulations on property relations, inheritance law, compulsory law of the receiving and sending states. It is particularly necessary to know and apply administrative procedure in terms of principles and procedural legal actions and procedures that are carried out during the performance of consular duties. Consular duties, unlike diplomatic duties, are characterized by the fact that they are of a specific administrative or legal nature. Therefore, a necessary condition for the consular function is

the application of the norms of international law, the norms of the receiving state and the norms of the sending state, depending on the legal matter that is in the process before the consular office. For the purpose of the research, the scientific and research subject of the work was defined, which includes the historical and ontological dimension of the international legal institution of the consulate and consular law, with a special focus on the codification and adoption of the Vienna Convention on Consular Relations, as well as other documents regulating the area of consular law, the general legal conceptual and content-functional structure of consular affairs, the international legal treatment of the consular function, the normative determination of the structure and functions of the consular function in the Vienna Convention on Consular Relations, and fairness of law in the context of the Vienna Convention on Consular Relations. The aim of the work is to highlight and point out all important relevant legal theories and factors of a legal and political nature, the structure of legal institutions of consular functions and consular affairs and social implications, as well as the specifics and legal position, roles and functions of consular affairs, noting that the problems of the consular office and affairs, to a lesser or greater extent, occur in an identical way in all states. The work presents general legal theoretical knowledge, positive legal solutions as well as some practical experiences in the realization of consular functions. The basic research goal is to determine in a scientifically objective manner the nature, legal determination, form and functions of consular offices and consular affairs in the context of the Vienna Convention on Consular Relations, in order to provide a contribution to the scientific understanding of the problem, i.e. the acquisition and deepening of scientific theory on the essential issues that scientific thought deals with when it comes to consular law, as well as to include research and analysis of indicators of the completeness and adequacy of the provisions of the Vienna Convention on Consular Relations. According to the complexity of the subject of the work, its complexity and multidimensionality, for its explanation there is a need for a functional, structural, deductive, inductive and systemic,

ethological approach. Based on the topic, the subject of the work and the stated goal and tasks of the work, the following hypothetical assumptions were made: that the Vienna Convention on Consular Relations contributed to the process of strengthening consular relations, the role, mission and functions of consular missions and in a certain way influenced the unification of procedural legal actions and procedures that are carried out in the conduct of administrative procedures within the framework of consular affairs; that through its historical origin and development, the consular function has retained its properties and function and that, despite numerous weaknesses, due to its ideological and theoretical strength, it has remained an integral part of international public law in all states in the world; that the fundamental role and mission of consular affairs is in administrative and professional-legal affairs that are aimed at protecting the rights of the sending citizen in relation to the legal system of the receiving state; that there is a polyvalence of the consular function, in terms of the work that consular offices perform in accordance with the law of the receiving state and the work that consular departments perform in the application of the legal system of the sending state.

## **2. CONCEPT, ORIGIN AND DEVELOPMENT OF THE CONSULAR FUNCTION**

In order to better understand the function and organization system of the consular function, it is necessary to approach it from its ontogenetic point of view, that is, to determine the patterns of origin, primary function and historical development of the consular function, including the factors that determined what kind of model the consular function will be in a certain time. In this direction, it is important to determine the very meaning of the concept of consular functions, both etymologically and substantively. Consular functions had different specific values in their origin and their social influence had completely different elements, in particular, that for many years the consular function was beyond the reach of international public law. International public

law was established only during the 19th century, and in the 20th century it acquired the necessary dimension that corresponds to the requirements of international economic and political relations. Legally and logically, it is an indisputable fact that the consular function is an integral part of the functions of international law, that it is determined by legal norms of a public law character and that its understanding is impossible without first accepting the viewpoint of international law in general, and especially of diplomatic-consular law and finally of consular law itself. The concept of consular law is extremely complex and intricate. Its understanding is influenced by a number of determinants of a legal and political nature, and consular law is both an integral part of diplomatic law and its specifics (Omerović, 2025). In this context, it is necessary to reveal the origin and constellations of diplomatic law, from which consular law also emerged. Diplomacy is accepted in its basic meaning as the management of international relations through negotiations. The terms diplomacy and diplomat have been in general use since the 18th century, and etymologically the word diplomacy derives from the Greek word *diploma*, which means document, but also the meaning of paper that was folded. The emergence of modern diplomatic services occurred after the division of the Roman Empire in 395, and it developed rapidly only from the mid-17th century, and then certain ideas and requirements were formed when it came to the diplomatic function. In its origin and functions, the diplomatic function had a number of functions, and was heterogeneous because it was treated differently in some states. However, during the 18th and 19th centuries, diplomatic and consular functions crystallized, and after that, during the 20th century, with the development of international law, there was also the codification of diplomatic and consular law and, of course, the unification of procedural legal norms governing the organization, functions and obligations of consular bodies. The definition of the term diplomatic functions and diplomatic law most often includes the definition of the term consular law (Đorđević and Mitić, 2000). Diplomatic law is primarily defined as a part of international

public law, and then as a legal branch, which consists of rules that regulate diplomatic and consular relations in the international community. These are the relations between states, and between states and international organizations. Legal theory considers these rules to be the earliest and most authentic source of public international law (Avramović, 2006). Throughout history, it happened that groups of independent states maintained relations in a kind of coexistence. In such situations, special customs were formed about their mutually established different relationships, and over time these relationships turned into customary norms and unwritten rules. The functional meaning of the term diplomacy is also found as an instrument that protects national interests, ensures the implementation of a certain policy, influences public opinion in other states and in the international community as a whole. It is necessary to know that the concept of diplomacy is much broader than administrative tasks, which in this context are performed in a state for the citizens of another state. What characterizes diplomatic relations is the fact that they are established even in the war relations of some states and function independently of whether there is a state of war or not. These relations take place and are established through the competent bodies of the state government or international organizations, which carry out certain diplomatic missions. In its basic meaning, consular law is a set of international legal rules that govern the relations of consular missions, their rights and duties in relation to the consular service, its activities and consular bodies. Accordingly, consular law regulates consular rights, obligations and responsibilities and consular relations, their establishment and content, and the activities of the bodies that exercise them. In this sense, consular law is an expression of international public law's efforts to regulate relations between consular bodies and the functions they have in a concrete way. Requests for such functions of consular law followed only in recent times. The problems of the legal position of foreigners, the fluctuation of capital and labor force and the need to improve economic relations in the world conditioned the tendency of almost all states in the world to have

a uniform way of regulating certain types of international relations, and the act of their codification and unification. This was also the reason for the development of consular law and its establishment as a subject dealt with by international public law. Until the adoption of the Vienna Convention on Consular Relations, the usual norms of international law were valid. It should be noted that the Vienna Convention on Consular Relations itself stipulates that relations between states that are not its signatories will be established relatively normative relations, either through bilateral agreements, contracts, or through the application of norms of customary international public law (Degan, 2006). From this, it can be concluded that there is a pronounced tendency for consular functions and consular relations to undergo codification, and it is especially important that they be unified in order to enable the realization of the human rights of foreigners and the economic efficiency of all states through an unimpeded or the simplest system of flow of goods and capital between states.

## **2.1. Consular function**

Consular missions are mainly focused on the authority of immediate affairs for the citizens of the state they represent. Basically, the consular function has an administrative legal character and belongs to the domain of public law. During the history of diplomacy, the consular function established certain rules that were primarily the subject of legal theory and legal science, and then consular law was formed. In its definition, consular law defines its content and subject of study. From the determination of the content of consular law, it follows that it is a set of legal rules that regulate consular relations, their establishment and content, and the activities of the bodies that implement them. After the establishment of consular law, there followed a series of bilateral treaties and multilateral agreements on consular affairs, and finally, in the middle of the 20th century, there followed conventions that regulated consular relations in a general way, which until then were mostly uniform and somewhat unified, and consular affairs were performed with the application of

customary norms. For this purpose, the bearers of consular functions are consular offices, namely the consulate general, consulate, and vice consulate or consular agency, as well as diplomatic missions. In accordance with the Vienna Convention on Consular Relations, consular functions include the protection of the interests of the sending state and citizens in the receiving state, within the framework of international law or a bilateral agreement between the receiving state and the sending state, with the provision that the sending state's laws apply to the sending state's citizens and that the consulate must take care of them (Dimitrijević, 2007). The consular function also includes promoting the development of relations between the sending state and the receiving state, the character of which is more of a political nature, but in a certain sense, the consulate's activities specifically support the development of economic and trade relations. The consular function also has the role of collecting information and providing information about the receiving state, which is slowly losing its effect due to the development of digital technologies and the availability of information. The consular function also consists in the performance of direct administrative and professional services, which consular departments provide to their citizens who have the status of a foreigner in the receiving state, that is, to citizens of the receiving state who want to travel to the sending state on various grounds, in which performance the principles and procedural-legal actions of administrative law and administrative procedure are applied. Most often, this refers to the issuance of personal documents and visas. The consular function also refers to the provision of various types of assistance, most often advisory, for persons who are from the sending state and want to perform some legal action, such as the conclusion of a contract, transfer of ownership, inheritance rights, trade, business relations and the like. Consular functions also include certification of appropriate documentation, statements, photocopies of documents, mediation of obtaining documents from registry offices and the like. In this sense, the Vienna Convention on Diplomatic Relations limits this right and the consular function and binds it to the domestic

regulations and jurisdiction of the receiving state. Consulates also provide information on heirs and perform certain representation services in inheritance relations, within the framework of the legislation of the receiving state (Micu, 2020). The consular function also includes the protection of the interests of minors and other legally incompetent persons, in certain cases the obligation to carry out the procedure for appointing guardians and assuming certain rights and obligations, on behalf of minors or persons deprived of legal capacity, who have certain rights and obligations in the receiving state. Its role is also to participate in the procedure for taking measures to ensure appropriate representation before the courts or other bodies of the receiving state, in order to protect the rights and interests of its citizens, when they cannot defend their rights and interests in a timely manner, as well as all other functions that the sending state entrusts to the consular office, and are not prohibited or not opposed by the receiving state.

## **2.2. Consular relations**

An essential category of consular relations is consular capacity, which refers to international legal legitimacy exclusively of the state, and not of other international legal entities. The sending state needs the prior consent of the receiving state for the purpose of opening consular offices, their headquarters and scope of work, as well as the appointment of consular officials. International law, as well as the Vienna Convention on Consular Relations, does not stipulate reciprocity of consular relations, which means, for example, that the sending state, in order to open a consular office, does not have to grant this right to the receiving state beforehand. The Vienna Convention on Consular Relations stipulates that for the consent to establish diplomatic relations between two states, consent for the establishment of consular relations is also required, unless otherwise stipulated by a bilateral agreement between the two states. As a presumption, tacit consent is sufficient for the establishment of consular relations. The issue of breaking consular relations between states is also specific. The Vienna Convention on Consular Relations provides that the termination of diplomatic

relations does not automatically mean the termination of consular relations, which can therefore exist in all their functions, regardless of the existence of diplomatic relations between states (Berković, 1995). This is possible given the character and functions of diplomatic relations, unlike consular ones, and it should be taken into account that diplomatic affairs are political in nature, and the condition for their existence is the establishment of good political relations between two states. In contrast, consular affairs have a legal administrative character and can be carried out in accordance with legal systems regardless of the value component. In this regard, the function of public international law is very important. Consular relations between two states cease in cases where both the receiving and sending states agree to this and sign an agreement on the termination of consular relations with clearly defined elements of the termination of consular relations; upon the outbreak of war between the receiving and sending states, because the state of war prevents the smooth performance of consular affairs, and it can be assumed that the need for them has rapidly decreased due to the war; and if there is a loss of international subjectivity, because consular, as well as diplomatic, relations can only be established between internationally recognized states. In the event that one state, whether the receiving or sending state, loses international legal subjectivity, it is automatically considered unable to establish consular relations. There is no doubt, and what follows from the Vienna Convention on Diplomatic Relations, that consular relations are almost assumed between all states in the world, and that this is an international legal standard. In this sense, the Vienna Convention on Diplomatic Relations states that since ancient times consular relations have been established between nations, which indicates that the status of consular representative is an integral part of customary international law and that the assumption is that there is a willingness in all states to establish consular relations, which is an attitude that does not apply to diplomatic missions. The Vienna Convention, in addition to codifying the norms of consular law and unifying certain consular procedures in a certain way, brings the status of consular officials closer to that

of a diplomatic representative, thus making it clear how important consular relations and consular affairs are for the international community. Considering that a significant part of human rights is realized through consular affairs, by affirming consular relations and affairs, the Vienna Convention makes a move in the direction of strengthening the position for the realization of human rights. In performing consular duties, sending states may, depending on their needs and possibilities, as well as the norms of international public law, have different forms of performing consular duties in the receiving state. A consular office is the most adequate body for performing consular duties. Consular offices, in any variant, do not perform political duties or duties related to relations with the government or one of its ministries of the receiving state. Unlike a diplomatic representative, who represents his state in the receiving state, a consular official does not represent his government towards the government of the receiving state. This means that he has no diplomatic significance or function, but has predominantly non-political functions. Consular offices perform administrative duties for citizens who are foreigners in the receiving state. Globally speaking, these most often concern status issues of citizens of the sending state, then tasks of representing citizens of the sending state and tasks of a different nature. The duties of consular missions do not have diplomatic significance, but only certain non-political functions in accordance with the Vienna Convention on Diplomatic Relations and other acts of international public law. Regardless of the category of consular officials, whether they are career consular officials or honorary consular officials, they must perform specific tasks of an administrative-professional nature and fulfill obligations in accordance with the regulations and deadlines established in the regulations for the implementation of a special administrative procedure. Consular officers have special treatment in consular offices. These are persons who perform administrative-professional or general tasks of a consular or other nature in the consular office. It should also be noted that the notification to the Ministry of Interior of the receiving state must also be made in the case of

family members of the head of the consular office. The notification must state the exact date of arrival or departure of family members of the head of the consular office (Berković, 1995). Consular relations are part of international public law and are based on the type, character and content of relations between states. In relations between states, the norms of international law, customary norms, which have arisen in the course of history, are applied. Legal science, especially international law and with it consular law, has determined the general legal principles of international law that are contained in international law (Lapenda, 2007). On the basis of these principles, the legal principles of relations between states have been singled out, which directly or in a certain sense indirectly affect consular relations and consular affairs. Although there are general legal principles, principles of international law, as well as special principles, which exist in every legal branch and discipline dealt with by international public law, through the relatively short history of international law, principles have crystallized that affect consular relations and consular affairs to a certain extent. They are to a lesser or greater extent connected with consular relations and consular functions. Their application and compliance is mandatory for both the receiving and sending states.

### **2.3. Privileges, immunities and privileges of consular staff**

The Vienna Convention on Consular Relations regulates privileges and immunities in order to contribute to the promotion of friendly relations between states, regardless of the differences in their constitutional and social systems. The purpose of privileges and immunities is not to create preferential treatment for individuals, but to ensure the effective performance of the functions of consular posts. The premises of the mission are inviolable, as are the archives and documents of the mission, while the personnel, during the performance of their duties, are protected by the receiving state, with the aim of enjoying personal inviolability and the impossibility of being subjected to arrest or detention. Consular officials and consular officers are not subject to the jurisdiction of the judicial and administrative

authorities of the receiving state for acts committed in the performance of consular functions, but not in the case of civil lawsuits initiated on the basis of a contract concluded by a consular official or consular officer (Berković, 1995). In today's modern world, the importance of diplomatic and consular functions is becoming increasingly pronounced, and in this sense, there are numerous academic works that deal with issues of diplomatic and consular rights, although they all mainly rely on sources of law of persons performing diplomatic and consular duties. In order to analyze the diplomatic-consular rights and privileges, it is necessary to consider what all the obligations are in the context of the performance of diplomatic and consular duties performed by the person, i.e. which rights derive directly from legal sources, and which have essentially been established over a certain time, as customary rules, which results from the basic function of diplomacy.

Based on the obligations and tasks of the diplomatic-consular mission, a number of legal and factual situations arise with defined or undefined legal or customary status and authorizations of persons who perform these tasks on behalf of diplomatic-consular missions. It is an established opinion that these are jobs of special state interest and that the people who perform them are especially trustworthy. Thus, there are privileges enjoyed by persons who perform important tasks for the state, and which arise not only from the fact that these are tasks of special interest, but also because certain legal and factual prerequisites need to be created for this type of tasks so that the persons performing them can perform them as quickly and efficiently as possible. That is why these people must be given certain social privileges that they can use in the context of the aforementioned principles of efficiency and speed. Therefore, according to the aforementioned status and procedural rights, it can be concluded that the members of the diplomatic-consular mission are in a special, relatively privileged position and that they are granted greater rights compared to the local population. Legal theory especially accepts the issue of not being subject to the legislation of the

host country, which can be a reason for certain practical abuses to a considerable extent. In addition, from a security point of view, the complete inviolability of transcripts, communications and apartments inhabited by persons working in diplomatic consular missions, along with a number of other factual situations, which can be used in a negative way by persons working in diplomatic bodies, seems controversial. In order that there would be no absolute freedoms in the granting of privileges that could affect the security of the host country, the Vienna Convention also provided for certain deviations from these absolute rights. Accordingly, the privileges and immunities of the diplomatic and consular missions, those related to the work of the mission, and the privileges and immunities of the members of the consular mission differ. In addition to the privileges of the mission and its work, such as the inviolability of premises, protection of archives and documents, immunity of means of transport, inviolability of residence, and freedom of communication, the privileges and immunities of the members of the consular mission should be mentioned, namely the inviolability of the person, immunity from jurisdiction and freedom of movement. In any case, it is necessary to appreciate the fact that the Vienna Convention made clear distinctions between the holders and types of privileges granted by it, and that it distributed them accordingly, all with the aim of a better and more efficient organization of the consular mission.

#### 2.4. The significance of the Vienna Convention on Consular Relations in the context of the fairness of the rights and position of foreigners

It is generally known that the process of codification and unification of norms, both substantive and procedural, is of crucial importance for the functions of consular law. In this context, the enactment of the Vienna Convention on Consular Relations and other international legal acts, which regulate the organization and work of consular offices, consular affairs, and the rights and obligations of consular employees, represented a great advance in the direction of normalizing relations that until then were governed by the principle of customary

law. Legal norms codify customary norms and establish the manner of relations between the receiving and sending countries. The features of the Vienna Convention on Consular Relations are indisputable, especially in two segments, for the codification and unification of the norms of customary international public law, which refers to consular law, and strengthening the legal position of foreigners in the context of creating more favorable conditions for legal predictability and legal certainty of foreigners. While the first feature of the Vienna Convention on Consular Relations can be said to fall within the domain of real and expected processes, from the perspective of public international law, the second feature can also be classified in the area of philosophy of law and the fairness of law. If we treat the fairness of law from a formal perspective, then the Vienna Convention can be said to be fair because, by codifying and unifying consular relations and consular law, it contributed to the establishment of legally established relations and, in a necessary manner, regulated the relations between the receiving and sending states, the organization, working methods and functions of consular offices and the rights and obligations of consular officers and the head of the consular office. The Convention thus introduced a formalized order that, although it existed in a procedural sense, these norms were unwritten or were fragmentarily established in the customary law and practice of many states. In terms of content, the Vienna Convention, by establishing a normative order in the field of consular relations, has contributed to creating conditions for the exercise of the rights of foreigners who, as citizens of the sending state, find themselves in the receiving state, where they need to exercise certain rights. These are a number of rights in the domain of property-legal relations, family relations, inheritance rights and rights based on administrative and civil proceedings. For these reasons, the establishment of the Vienna Convention in international public law is a significant contribution to the fairness of law, and it is a certain contribution to the fairness of law, while respecting the dimensions of the exercise of human freedoms and rights. (Subašić and Čupurdija, 2015).

## CONCLUSION

The paper pointed out the essential elements and factors that determine the consular function and highlighted the norms of the Vienna Convention on Consular Relations, as a fundamental legal act for the organization and functioning of consular offices. Also, the paper presents a critical overview of the effects of privileges and immunities, which the officers and heads of consular offices have. One can hardly talk about the balance of arguments for or against, because in the end, the only stronger argument for the existence of the institute of privileges and immunities was an extralegal, not a legal argument, that is, the very existence of privileges to a certain extent discredits legality and law. The paper also confirmed the hypothesis that the Vienna Convention on Consular Relations, which led to the codification of customary norms of international public law, contributed to the process of strengthening consular relations, the role, mission and functions of consular missions and in a certain way influenced the unification of procedural legal actions and procedures, which are carried out in the conduct of administrative procedures within the framework of consular affairs. Special hypotheses confirmed the general hypothesis, and in the segments they treat, they confirmed that through the historical origin and development, the consular function has retained its properties and functions, and despite numerous weaknesses, due to its ideological and theoretical strength, it has remained an integral part of international public law in all states of the world. The conceptual foundation of the existence of the consular function is a humane goal, derived from the legal theory of natural law and the human freedoms and rights based on it. In most states there are consular representations of other states, sending offices, and as such, they are an integral part of the foreign policy system of every state in the world. The adoption of the Vienna Convention on Consular Relations specified the organization, organization and competences of consular offices, and therefore it can be concluded that the fundamental role and mission of consular affairs is in administrative and professional-legal affairs, which are aimed at protecting the rights of the

sending citizen in relation to the legal system of the receiving state. The Vienna Convention on Consular Relations, as a fundamental act, regulates the content of powers, conditions, manner, procedure and procedures to be followed in the process of issuing certain acts or undertaking certain legal actions in favor of exercising the rights of the sender's citizen in the receiving state. Such procedures and the notification procedure serve the purpose of creating strict procedural rules and preventing dysfunctions in the field of consular relations between the receiving and sending states. For the relative stability of the performance of the consular function, the existence of privileges and immunities is necessary, which results from the character of consular duties, which should not be restricted. This particularly refers to freedom of movement, non-punishment for minor traffic violations, freedom of communication and immunity from criminal law with certain limitations. Emphasized privileges can sometimes, to a certain extent, produce a feeling of inequality among people before the law, and in the modern world they lose their meaning and utility value. The existence of polyvalence of the consular function is present, both in terms of the tasks that consular offices perform in accordance with the law of the receiving state and the tasks that consular departments perform in the application of the legal system of the sending state. Polyvalence also applies to numerous branches of law that are used in the work of consular offices, such as family law, property law, inheritance law, compulsory law, and especially administrative law and administrative procedure. The most important thing is that when obtaining documentation and when issuing certain certificates and certificates for citizens of the sending state, the provisions of the law on administrative procedure must be directly applied. In the process of drafting individual legal acts and the process of undertaking certain factual actions of consular affairs, the Vienna Convention on Consular Relations is applied in the function of justice of law, which arises from the fact that it has codified the norms of international public law that relate to consular law. It follows from everything that, thanks to the Vienna Convention

on Consular Relations, today we have codified norms of consular law from the point of view of their immediate application and unified actions and procedures of consular bodies, as well as that today's model of consular law is adequate to the needs of all states in the world. Unlike the diplomatic function, which derives its foundation from the politics of interstate and international political relations, the consular function is in the service of the immediate realization of the freedoms and rights of citizens. This can be especially noted for the rights of foreigners in a state. It remains to be seen what further impact the Vienna Convention on Consular Relations will have, especially if we take into account the changes taking place in the field of administrative law and models of electronic and modern administration. It is necessary to consider the possibility that some consular, namely administrative functions, in accordance with the already started practice of concluding reciprocity agreements, be relocated from the receiving state to the sending state and vice versa. This would mean the gradual abolition of some consular functions. Like all social processes, the consular function is subject to changes over time, and it can rightly be assumed that a more pronounced scientific and lay critical reception of the model of consular affairs and consular offices and their social and interstate effects will soon follow, and that legal science, and especially Consular Law, will be challenged to determine the future of the consular function and the model established by the Vienna Convention on Consular Relations.

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## SPATIAL ANALYSIS OF DISASTER LOGISTICS IN SLOVENIA: A CASE STUDY OF CELJE AND THE 2023 FLOODS

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### Abstract

*Abstract As a result of climate change, the increase in the frequency and intensity of hydrometeorological disasters necessitates a reassessment of traditional disaster management strategies and logistical planning. Slovenia's geographical and hydrogeological structure, combined with the flood disaster that occurred in August 2023, has pushed the limits of the existing civil protection infrastructure. This research presents a spatial analysis of a two-echelon distribution network design for humanitarian aid logistics in the context of Slovenia's multi-hazard profile. The study focuses on the Thiessen Polygons (Voronoi Diagrams) analysis, a direct GIS-based geometric solution method, and validates the results with the Set Covering Problem (SCP), a mathematical optimization model, to ensure network resilience. The report is based on the manual identification of potential logistics depot locations in the Celje region. The resulting geometric service areas were overlaid with flood risk maps to analyze accessibility constraints.*

JEL classification: R41, R49,  
H84



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# 1. INTRODUCTION

## 1.1 Background and Significance of the Study

Humanitarian aid logistics differs fundamentally from commercial supply chain management: the objective is not to maximize profit, but to alleviate human suffering and prevent loss of life. The first 72 hours of a disaster, known as the "golden hours," are critical for delivering essential supplies (Rawls & Turnquist, 2010; Balcik & Beamon, 2008). However, disasters often destroy the very transportation infrastructure required for this delivery. Due to its location at the intersection of Alpine, Dinaric, Pannonian, and Mediterranean climates, Slovenia is highly vulnerable to hydrometeorological risks (IFRC, 2024).

Traditional facility location models typically minimize cost or maximize coverage under the assumption of a functional network. However, the August 2023 floods in Slovenia demonstrated the fragility of this assumption. The collapse of major arteries and the isolation of settlements in the Savinja Valley highlighted the urgent need to prioritize "resilience" over "efficiency" in logistics planning (WTW, 2023).

## 1.2 Problem Definition: Slovenia's Disaster Profile

While Slovenia must adopt an "all-hazards" approach, the most destructive logistical scenarios are those that physically disrupt the transportation network.

### 1.2.1 Flood Risk and the August 2023 Disaster

The August 2023 floods were the most costly natural disaster in Slovenia's history, with damages estimated at €9.9 billion (Bezak et al., 2023). Hydrologically, this event provided critical lessons for logistics:

**Preliminary Conditions:** The first half of 2023 was exceptionally rainy, and by July, the soil was saturated and had lost its water retention capacity.

**Meteorological Bomb:** Mediterranean and Adriatic sea water temperatures were 2°C above average, increasing atmospheric

instability and resulting in rainfall exceeding 200 mm within 12 hours

between August 3 and 6 .

**Infrastructural Collapse:** This extreme rainfall not only caused rivers to overflow but also triggered large-scale landslides and morphological changes in riverbeds. The collapse of bridges over the Savinja River and the flooding of roads brought logistical operations in regional centers like Celje to a standstill.

Table 1: Critical Infrastructure Damage in the August 2023 Floods

| Region         | Affected River | Type of Damage                           | Logistics Impact                                               |
|----------------|----------------|------------------------------------------|----------------------------------------------------------------|
| Savinja Valley | Savinja        | The main transportation bridge collapsed | Luče and Solčava were isolated, an air bridge was established. |
| Kamnik         | Kam. Bistrica  | Godič Bridge collapsed                   | Local transportation has been suspended.                       |
| Koroška        | Meža           | Roads and bridges were destroyed         | Črna na Koroškem experienced complete isolation.               |
| Mura Basin     | Mura           | Set tear (Krapje Veržej)                 | Evacuation and dam reinforcement logistics were required.      |

### 1.2.2Logistics Blind Spots

Existing civil protection warehouses and commercial logistics centers (e.g., Intereuropa, Pošta Slovenije) are traditionally located near highway networks on flat terrain for economic efficiency (Intereuropa, 2024). However, in the Celje basin, these "flat terrains" correspond to floodplains. A systemic vulnerability exists where either the depots themselves or the roads

connecting them to demand points are located in high-risk zones.

### 1.3 Purpose and Scope of the Study

This research aims to visualize and quantify this vulnerability using Geographic Information Systems (GIS) and mathematical optimization. The study specifically addresses the following research question: How resilient are service areas created through Thiessen polygons when overlaid with flood risk maps? The methodology involves:

- (1) Manual identification of potential depots in Celje;
- (2) Generating theoretical service areas using Voronoi diagrams;
- (3) Analyzing accessibility constraints by overlaying Q100 flood maps; and
- (4) Validating the results using a Set Covering Problem (SCP) algorithm.

## 2. Literature Review: Site Selection and GIS in Humanitarian Aid Logistics

This section examines the academic literature that forms the theoretical basis of the study, particularly in the context of hierarchical site selection, the use of Voronoi diagrams, and disaster logistics.

### 2.1 Hierarchical Models in Humanitarian Aid Logistics (HFLM)

Humanitarian supply chains, unlike commercial chains, are characterized by uncertainty, high demand fluctuations, and infrastructure damage. To overcome these challenges, Two-Echelon or Hierarchical Facility Location Models (HFLM) are frequently proposed. These models typically consist of two levels: strategic Main Distribution Centers (MDC), which are permanent facilities located near international entry points (Rawls & Turnquist, 2010), and operational Local Distribution Centers (LDC), which are flexible structures positioned closer to the disaster area. Yilmaz and Kabak (2024) demonstrated that the simultaneous optimization of these two levels significantly shortens the response time. In flood scenarios, these local warehouses must be capable of autonomous operation when cut off from the main network.

### 2.2 Spatial Analysis and Voronoi Diagrams

Voronoi diagrams (Thiessen polygons) partition a

plane into regions based on the nearest neighbor principle. Boonmee et al. (2017) highlight that

Voronoi diagrams are ideal for rapidly defining a "catchment area" without requiring complex network data, particularly in the initial chaotic phase of a disaster. However, a major limitation is that they rely on Euclidean (bird's-eye) distance. In mountainous regions like Slovenia, a short Euclidean distance may correspond to a long or impossible travel route due to terrain (ArcGIS Pro Documentation, 2024). This study utilizes this limitation as an analytical tool: by identifying where flood barriers intersect idealized polygons, the "bottlenecks" in the system are revealed.

### 2.3 Logistics Lessons Learned from the 2023 Flood

Field reports from the August 2023 disaster document the devastating impact on logistics infrastructure. Bezak et al. (2023) noted that the floods reached 500-year recurrence intervals, causing significant damage. The most critical finding for logistics was the vulnerability of river crossings; the collapse of bridges in the Savinja Valley isolated upstream settlements such as Luče and Solčava for days (ReliefWeb, 2023). This demonstrates that "accessibility reliability" is a more critical parameter than geometric proximity in facility location selection.

### 3. METHODOLOGY: SPATIAL ANALYSIS WITH GIS

#### 3.1. Data Acquisition and Preparation

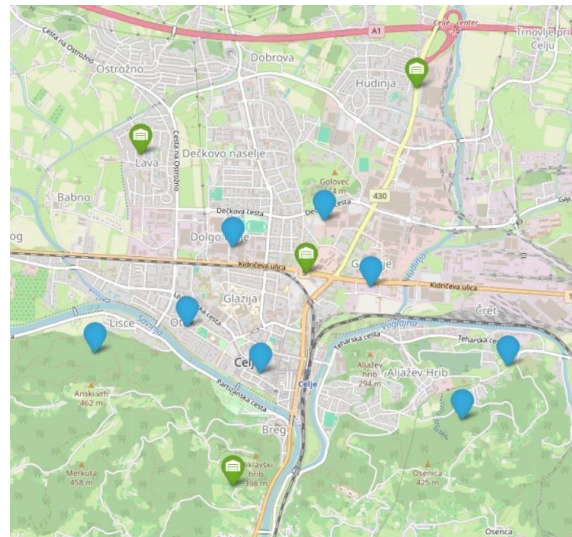
The success of any GIS analysis depends on the quality of the spatial data. This study utilizes three primary datasets to model the logistics network in Celje:

1. Potential Facility Locations (Point Data): Existing logistics centers (e.g., Intereuropa, Pošta Slovenije) and safe public structures (e.g., Zlatorog Hall) were manually identified based on atlas data and local topography. These points represent candidate Main Distribution Centers (MDCs).
2. Demand Points/Risk Zones (Point Data): High-density residential areas and critical infrastructure points in the Celje basin were mapped as demand locations where humanitarian aid would be required.
3. Hydrological Data (Flood Risk): The Q100 (100-year return period) flood spread maps, provided by the Slovenian

Environment Agency (ARSO) and Copernicus EMS, were used to represent the physical barriers affecting the network (European Commission, 2023).

#### 3.2 Data Visualization with Python (Folium)

Before applying complex spatial algorithms, the distribution of risk zones (8 points) and potential depots (4 points) was visualized to understand the spatial context. The Python programming language and the 'Folium' library were employed to generate an interactive map layout (Python Software Foundation, n.d.). This step allowed for a preliminary assessment of the physical distribution of points on a satellite map.



*Figure 1: Interactive Location Map created with Python (Folium), showing risk zones (blue) and potential depot locations (green).*

#### 3.3 Creating Thiessen Polygons (Voronoi Diagrams)

The delineation of service areas was performed using the "Create Thiessen Polygons" tool within the Analysis toolbox of ArcGIS Pro. This geometric approach, mathematically known as Voronoi tessellation, partitions the study area into regions based on the nearest-neighbor principle. Consequently, any location within a generated polygon is closer to the associated depot than to any other facility in the network.

A critical technical step in this process was the definition of the spatial reference system. Given that the analysis relies heavily on Euclidean distance calculations, the project was strictly defined using the D96/TM (Slovenian National

Grid) projected coordinate system. Using a geographic coordinate system like WGS84 would introduce significant distortions in area and distance measurements, leading to inaccurate service boundaries.

Furthermore, to ensure the analysis remained relevant to the administrative and operational scope, the "Processing Extent" environment setting was constrained to the Celje municipality boundary. This prevented the generation of infinite polygons at the outer edges of the point set (convex hull). The resulting vector layer represents the theoretical "dominance area" of

each manually selected depot. For visualization purposes, these polygons were rendered with 50% transparency to allow for the simultaneous assessment of underlying topographic features and flood risk zones.

### 3.4 Flood Risk Overlay Analysis

Thiessen polygons alone only indicate geometric proximity based on a barrier-free surface. To assess the "resilience" of the proposed network, a critical overlay analysis was performed by integrating hydrological data into the GIS environment.

The process involved superimposing the Q100 (100-year return period) flood risk map and the August 2023 event map onto the generated Thiessen layer. This visual intersection analysis aimed to answer a critical research question: Does the flood hazard affect the facility location itself (point) or the accessibility of its service area (polygon)? The study identified two distinct failure scenarios:

**Scenario A (Depot Inundation):** If the point coordinate representing a candidate depot falls directly within the flood layer, the facility is deemed non-operational. Consequently, the entire associated Thiessen polygon is considered "offline," creating a significant service gap in the logistics network.

**Scenario B (Access Interruption):** A more complex failure occurs when the depot itself is located in a dry zone, but the floodwaters (e.g., the overflowing Savinja River) intersect the polygon between the

depot and its assigned demand points. In this case, the Thiessen polygon loses its validity; although the Euclidean distance suggests proximity, the actual physical access is severed, rendering the service area inaccessible.

### 3.5 Verification of Manual via GIS

The final stage of the methodology involved a GIS-based verification of the manually selected potential depot locations. The manual selection, initially based on expert judgment and atlas data, was rigorously tested against the  
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spatial analysis results:

**Risk Assessment:** Any manually selected storage facility that was found to be located within the Q100 floodplain during the overlay analysis was flagged as "high risk" and eliminated from the candidate list.

**Capacity and Coverage Check:** If a selected storage facility was confirmed to be in a safe zone but its resulting Thiessen polygon covered an excessively large geographic area (indicating a potential capacity overload or excessive travel time), the analysis concluded that an additional Local Distribution Center (LDC) must be established within that specific sector to ensure adequate coverage.

## 4. CASE STUDY: CELJE AND THE SAVINJA VALLEY

This section presents the results of the spatial analysis applied to the Celje region, incorporating data from the August 2023 flood disaster to validate the theoretical models.

### 4.1 Characteristics of the Region and Its Logistical Importance

Celje, Slovenia's third-largest city, is strategically located at the confluence of the Savinja and Voglajna rivers. While this location makes it a vital logistics hub, it also creates a significant hydrological vulnerability. During the August 2023 floods, the overflowing Savinja River caused extensive damage to the northern and western districts, severing connections towards Laško and the Upper Savinja Valley (ReliefWeb, 2023). The riverbed, which runs directly through the urban center, has a wide floodplain that inundates low-lying settlements and logistics zones during extreme events.

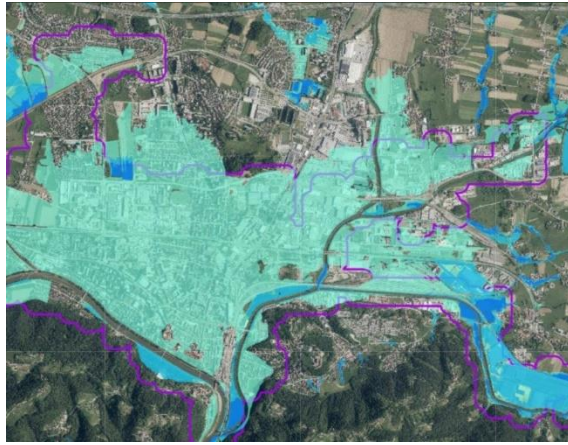


Figure 2: The floodplain of the Savinja River in Celje. The blue areas represent high-risk zones (Q100) where logistics operations would be compromised

#### 4.2 Analysis of the Thiessen Polygon Map

The Thiessen polygon analysis was applied to four manually selected candidate depots to determine their geometric service areas. The resulting map

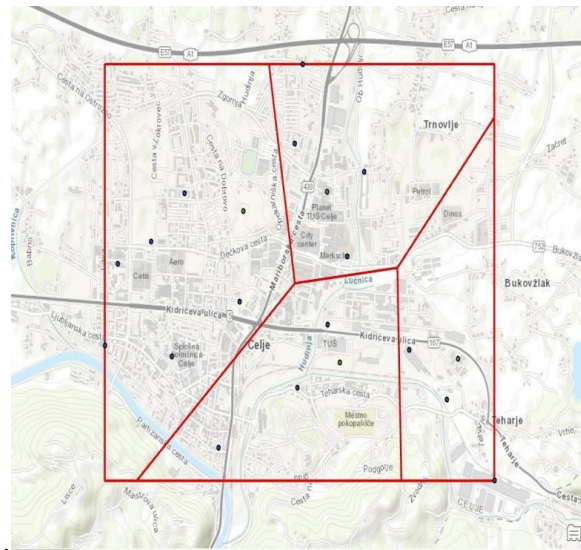


Figure 3: Proposed warehouse locations and their geometric service areas (Thiessen Polygons).

reveals the "dominance area" of each depot based on Euclidean distance.

The areas separated by red lines show the service areas of the selected storage points.

Observation 1: The boundaries of the polygons generally do not coincide with physical barriers such as rivers or main roads (a natural result of the Thiessen method). The boundaries are purely mathematical midpoints.

Risk Identification: For example, a depot on the left bank of a river may appear to serve a neighborhood on the right bank according to Thiessen boundaries. However, if the flood map (Figure 2) shows that bridges over the river are at risk or submerged, the neighborhood on the right bank becomes "unserved."

Conflict: If some depots in the center of Celje are observed to be very close to or within the dark blue (deep water/high velocity) areas on the flood risk map, selecting these depots as "Main Depots" (MDC) is a strategic error. These points can only be used during "temporary, low-risk periods."

#### 4.3 Lessons Learned from the 2023 Flood and Model Validation

In August 2023, many bridges were destroyed and roads were closed in the Savinja Valley.

- Logistical Disruption: Road connections between Celje and upstream towns such as Mozirje, Ljubno, and Luče were severed. Thiessen analysis may "geometrically" show that a depot in Celje could serve these areas, but "topologically" this has become impossible.
- The example of Črna na Koroškem: This town in the Meža Valley was isolated for days. This situation demonstrates that LDCs (local distribution centers) should be located not only for logistical efficiency (cost) but also to provide "autonomy." Every basin at risk of isolation should have its own self-sufficient LDC.

#### 4.4 Mathematical Verification: Set Covering Problem (SCP)

In the previous sections, we determined the service areas geometrically using Voronoi diagrams. However, we also wanted to verify these locations mathematically. Therefore, we adapted the 'Set Covering Problem' algorithm from our previous facility planning projects to the Celje case (Kolen & Tamir, 1987).

We used Python to calculate the minimum number of depots needed. We defined a 3.5 km service radius (R) for emergency vehicles because road conditions are difficult during floods.

The logic of the algorithm is simple:

We created a binary matrix (0 and 1).

If a depot is within 3.5 km of a risk point, the value is 1. If not, it is 0.

The code tests all combinations to find the best solution.

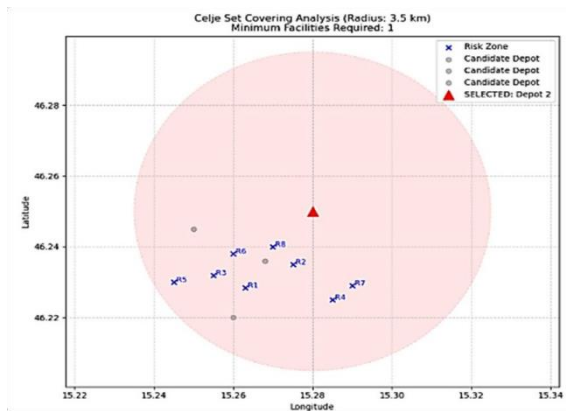


Figure 4: Mathematical validation result using Set Covering Problem (SCP).

Results: The Python analysis with a 3.5 km radius indicated that mathematically, a single strategic depot (Depot 2) is sufficient to cover all risk zones geometrically. However, relying on a single depot creates a single point of failure. Therefore, while the algorithm proves the high coverage efficiency of the northern region, our proposed multi-depot system (Figure 3) is maintained to ensure redundancy and resilience against potential bridge collapses.

## 5. DISCUSSION: BEYOND EUCLIDEAN DISTANCE

The Thiessen (Voronoi) approach used in this study serves as a powerful visual tool for the initial "rapid assessment" phase of disaster management. However, the application of this geometric method in a topography as complex as Slovenia reveals significant limitations that must be addressed in future planning.

### 5.1 Geometric Proximity vs. Network Access

In mountainous countries such as Slovenia, Euclidean ("as the crow flies") distances are often misleading. Two points may appear adjacent on a map, yet be separated by a mountain range or a river requiring a detour of several kilometers. Thiessen polygons, by definition, ignore these geographical barriers. While future research

should incorporate the Network Analyst module in ArcGIS to calculate travel times based on the actual road network, Thiessen polygons remain a valid reference for the "baseline" scenario, particularly when the road network status is unknown or highly dynamic during the first hours of a crisis (ArcGIS Pro Documentation, 2024).

### 5.2 The Effect of Flood Barriers

Floods act as a "dynamic barrier" on the logistics network. As water levels rise, passable routes decrease non-linearly. A critical finding of this study is that flood resilience cannot be determined solely by the location of the facility. Even if a selected warehouse is located outside the Q500 (500-year return period) flood zone, it is rendered useless if its "exit routes" are submerged. Thiessen analysis partitions the area but does not account for connectivity. Therefore, manual verification is essential to determine whether the boundaries of a service area coincide with a river, implying a reliance on vulnerable bridges.

## CONCLUSION

Slovenia's complex topography and increasing exposure to climate-induced risks necessitate a paradigm shift in disaster logistics: moving from static, cost-oriented planning to dynamic and resilient network design. This study presented a GIS-based optimization approach validated by infrastructure damage data from the August 2023 floods. The spatial analysis revealed that while geometric models (Thiessen polygons) can efficiently partition service areas, they often fail to account for physical accessibility constraints. Overlaying these models with flood risk maps demonstrated that many theoretically "optimal" depot locations could become inaccessible due to bridge collapses, particularly in the Celje and Savinja regions.

Consequently, humanitarian logistics networks in flood-prone regions must be designed with redundancy. Relying on a single central depot—even if mathematically sufficient—creates a single point of failure. The proposed multi-depot system, while more costly, ensures that relief operations can continue even if primary transportation corridors are severed. The methodology and technical workflow presented in this report provide a scalable framework for future academic and practical studies aimed at enhancing disaster resilience.

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## A MODEL OF LIFELONG TRAFFIC EDUCATION AS A FOUNDATION FOR PROACTIVE ROAD SAFETY

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### Abstract

*The traditional approach to traffic safety, which primarily relies on repressive measures and the training of candidates only upon reaching adulthood, shows limited results regarding the long-term change in participant behavior. This paper advocates the thesis that traffic education must be a continuous process starting in early childhood, when an individual first enters the traffic ecosystem as a pedestrian. By analyzing proactive education methods, the study explores how the early development of risk perception directly correlates with later responsible behavior as a driver. A special focus is placed on adolescence as a critical period for preventing risky behavior and "reckless driving" through professional lectures that precede formal training in driving schools. Concluding considerations indicate that the integration of traffic ethics into the primary and secondary education systems is the only sustainable way to systematically raise the level of traffic culture and reduce fatal consequences on the road network.*

JEL classification: I21, R41, K42



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## 1. INTRODUCTION

The current educational system treats traffic education as marginal, secondary content that is implemented through just a few isolated and theoretical lessons during the school year, and through the final, often exclusively pragmatic training of driver candidates. This fragmented and discontinuous approach overlooks a fundamental fact: an individual becomes an active participant in a complex traffic ecosystem from the moment of birth and their first steps in public space, not by the act of acquiring a driver's license. The lack of continuous education and early traffic socialization directly correlates with a low level of general safety and frequent deviant behavior among road network users, who perceive traffic rules as an imposed repression rather than an ethical standard of movement. A particular safety challenge is the child population, whose behavior patterns are naturally spontaneous, and whose cognitive processes are intrinsically unpredictable to other participants. Children in the developmental phase do not possess the biologically developed ability to precisely and simultaneously evaluate the speed and distance of a moving vehicle, nor can they predict the kinetic outcome of a potential conflict in space. Therefore, it is imperative that a proactive learning model tracking the psychophysical development of the child be implemented through the formal educational system. In the 21st century, traffic has evolved into a comprehensive, high-tech phenomenon that permeates a person's entire lifespan, which demands the development of a fundamental traffic culture that is not acquired by mere memorization of signs, but is internalized as a set of natural, self-evident, and morally binding norms of behavior. The ultimate goal of such a reformed, multidimensional approach is to create a system in which learned safe behavior ceases to be an instinctive avoidance of punishment and becomes an inseparable, integral part of an individual's personal identity and daily routine. Only through early, systematic, and scientifically grounded education is it possible to create stable cognitive maps in young participants, effectively suppress behavioral unpredictability, and

transform the current, delayed reactive safety model into a sustainable proactive civilizational standard that preserves human lives.

## 2. EARLY DEVELOPMENT (PRESCHOOL AND ELEMENTARY SCHOOL)

During the developmental phase encompassing preschool and early school age, children attain a high degree of motor skills that enable them to execute complex physical actions, such as sudden running, jumping, and rapid, non-linear changes in direction. An additional challenge is presented by the increasingly frequent use of micromobility devices, such as scooters, bicycles, and rollerblades, which allow the child to develop speeds that significantly exceed their perceptive capacities. Although physically exceptionally agile at this age (Lindov, 2008), their cognitive and neurological development has not yet reached the level necessary for the precise and simultaneous perception of time, space, and depth. What is critical from an engineering standpoint is the child's inability to adequately assess the kinetic energy of a moving vehicle, as well as a lack of understanding of the concept of a motor vehicle's stopping distance under various speeds and road conditions. This profound mismatch between physical mobility and cognitive immaturity results in behavior patterns defined in traffic engineering as spontaneous and extremely unpredictable. Such unpredictability acts as a permanent generator of high risk, because drivers often cannot timely anticipate a child's reactions, which are guided by an immediate impulse or external stimulus rather than the logic of the traffic flow. By introducing proactive learning at this stage, the goal is to bridge this gap by developing defensive mechanisms in children, teaching them that their physical speed must always correlate with a visual confirmation of safety, thereby directly reducing the probability of conflict situations in school and playground zones.

Current legislation primarily focuses responsibility on motor vehicle drivers; however, engineering practice points to serious challenges

caused by rapid and often unplanned urbanization. The construction of dense road networks in the immediate vicinity of educational institutions, playgrounds, and parks creates high-conflict zones. An additional complicating factor is visual barriers in the form of vehicles parked by residents and visitors. Due to their low anthropometric height, children are often completely obscured by parked vehicles, and their reflexive running out onto the roadway (e.g., chasing a ball or other object) leaves the driver with minimal reaction time, which frequently leads to accidents with fatal consequences (Lindov, 2008). In addition to cognitive limitations, physiological specificities of the sense of sight represent a significant risk factor in childhood. It is documented that peripheral vision in children is underdeveloped, with their horizontal field of vision being approximately 30% narrower compared to adults. This phenomenon, known as “tunnel vision” (Lindov, 2008), directly prevents children from adequately spotting objects and motor vehicles approaching from the side. From a traffic safety perspective, this physiological barrier means that despite being physically present on or near the roadway, a child is often unaware of an oncoming hazard outside their narrow focus of attention. This limited visual perception, combined with rapid and unpredictable movements, further confirms the necessity of engineering protective zones around school facilities and the need for intensive education on the rules of visual verification of the traffic flow before stepping onto the roadway. (ReLoaD 2, 2024)

From the aforementioned risks, it is clear that establishing institutional and operational synergy between traffic engineering, forensic experts, and the educational system is of crucial importance. Traditional, passive education must be replaced by systemic, interactive modules and continuous professional lectures that proactively raise the level of safety culture from the earliest age. The focus of such a model must be primarily directed toward training vulnerable, non-motorized participants (pedestrians and cyclists) (Mehanović, 2017), with a special emphasis on developing the ability to early recognize latent

hazards on the roadway, those threats that are not immediately visible but are predictable through an understanding of traffic processes.

In addition to acquiring the visual identity and meaning of traffic signage, with a particular emphasis on road markings and pedestrian crossing zones, children must adopt the internal logic of the traffic system. This implies understanding cause-and-effect relationships, such as the impact of weather conditions on visibility or the importance of establishing eye contact with the driver. Raising the overall level of traffic literacy and ethics represents not just a pedagogical goal, but a critical engineering strategy for risk reduction. In a society where traffic is a dominant factor of daily life, literacy in this domain becomes a necessary tool for preserving human lives within a high-conflict technical environment that every individual, without exception, daily and inevitably encounters.

### **3. ADOLESCENCE (HIGH SCHOOL)**

Modern driver candidate training practices, which are legally limited to reaching the age of majority, prove to be chronically delayed and insufficient for the effective prevention of deviant behavior among the youth within the current social context. The traffic education system within high school institutions should not be reduced to ad-hoc lectures or a marginal mentioning of legal regulations. (Mojoj BiH, 2024) On the contrary, it must be established as a continuous curriculum of traffic ethics, in which formal driving school training represents merely the final, technical phase, the crowning achievement of a multi-year process of adopting responsible behavior patterns. Introducing traffic education into high schools allows adolescents to gradually prepare for the role of a driver through risk analysis while they are still in the status of pedestrians or cyclists. This approach prevents the occurrence of "cultural shock" upon first entering a motor vehicle, as the candidate already possesses a developed attitude toward social responsibility and the consequences of risky behavior. Without this prior foundation, driving school training

remains reduced to the mere mastering of technical vehicle operations, while a fundamental shift in awareness is absent, directly generating young drivers who are technically capable but ethically and safety-wise underdeveloped.

In modern society, it is essential to create a new paradigmatic framework in which possessing a driver's license is no longer perceived as a mere, self-evident right acquired by biological majority. On the contrary, operating a motor vehicle must be positioned as a social privilege and a high responsibility, based on previously demonstrated, deep-seated knowledge and the cognitive maturity of the individual. This level of maturity cannot be achieved through an accelerated driving school course, but exclusively through the long-term integration of the traffic engineering profession into the high school system, thereby separating the learning process from the mere acquisition of a license. Only through systemic education can we ensure that new drivers enter the road network with a developed instinct for defensive driving, a skill that implies the constant anticipation of others' mistakes and proactive action to avoid conflict.

A key element of this process is developing traffic empathy, especially toward vulnerable participants such as children, the elderly, and cyclists. When a candidate learns through high school education to observe traffic from a pedestrian's perspective, they develop a natural tendency as a future driver to reduce speed in conflict zones, not out of fear of sanctions, but due to an internal sense of responsibility. The implementation of such an environment transforms the traffic culture from reactive (punishment after an accident) to proactive (accident prevention through ethics). In this way, the educational system becomes the foundation of proactive safety, creating generations of drivers who understand that their freedom of movement ends where the endangerment of another person's life begins. This approach is not merely a pedagogical ideal, but a necessary engineering measure for drastically reducing road mortality rates.

The period of adolescence is biologically and psychologically characterized by an increased affinity for risky situations and a tendency to test established boundaries. On the roads of Bosnia and Herzegovina, this phenomenon manifests itself through an alarming number of adolescents operating motor vehicles before acquiring the legal right to do so. As self-taught and inexperienced operators, these individuals enter complex traffic flows without an elementary knowledge of the rules of right-of-way or the meaning of vertical road signage. When the consumption of psychoactive substances and alcohol is added to this, despite legal prohibitions on distribution to minors, it creates an extremely high risk for traffic tragedies with irreversible consequences.

A specific aspect of risk within the adolescent population is the phenomenon of social validation, namely the need to seek approval within the primary peer group. During this developmental period, motor vehicles are frequently perceived as tools for achieving a higher social status and demonstrating dominance. This perception directly generates high-risk behaviors, including extreme speeding, aggressive overtaking, and performing dangerous maneuvers in populated areas. This problem is further compounded by the interaction within the vehicle itself. It has been proven that the presence of peers in a vehicle exponentially increases a driver's propensity for risk-taking, while passengers concurrently expose themselves to direct, life-threatening danger by performing actions that compromise vehicle stability or their own safety, such as leaning out of windows, climbing onto a moving vehicle, or distracting the driver. From an engineering standpoint, these actions drastically alter the driver's distribution of attention and increase reaction time in critical situations. Under such circumstances, the vehicle cabin becomes a high-distraction zone where the focus is not on the traffic flow, but on the social dynamics inside the car. Precisely because of this, education must also address the role of the passenger, developing an awareness that passive participants in a vehicle directly contribute to the (in)security of the drive. The goal is to transform

peer influence from negative (encouraging risk) to positive (detering unsafe actions), thereby creating a collective system of responsibility within the group.

To suppress these negative trends, it is essential to establish a strong correlation between the traffic engineering profession, the educational system, and forensic traffic accident reconstruction experts. Regular workshops (ReLoaD 2, 2024) and educational sessions must not be merely theoretical; they must include case studies from forensic practice, visual depictions of real-life consequences, and simulations of the forces acting during a collision. The goal of this proactive approach is to transform the mindset of young people from perceiving driving as entertainment to understanding vehicle operation as a responsible task within a high-risk system. The involvement of forensic traffic experts in educational processes represents a key step toward achieving a higher degree of risk objectification. Through this approach, abstract legal rules receive their real, physical confirmation. Direct insight into photo documentation from accident scenes, the analysis of vehicle deformations, and precise calculations of kinetic energy and stopping distances create a powerful reality factor that is necessary for correcting the behavior of young traffic participants.

For the adolescent population, which is developmentally characterized by a cognitive distortion known as the "sense of personal invulnerability, a direct collision with reality through forensic evidence represents one of the most powerful psychological correctives. The visual presentation of the exact consequences of speed inappropriate for conditions, loss of vehicle control, or driving under the influence of psychoactive substances ceases to be mere theory the moment it is backed by expert forensic analysis. A key element of this methodology is the demystification of driving as harmless entertainment through the interpretation of bio-mechanical forces generated during a collision. When an expert explains and visualizes how kinetic energy, which increases with the square of the speed is transferred to the human body and

internal organs within a deformed vehicle cabin, the adolescent gains insight into the physical relentlessness of a traffic accident. This form of education goes beyond mere intimidation; it is aimed at developing critical thinking and a deep understanding of the irreversible consequences that occur in a fraction of a second due to inattention, overestimating one's own abilities, or conscious violation of regulations. By utilizing authentic photo documentation from accident scene investigations and the calculation of brake skid marks, the educational process is transformed into a scientific-research session that forces the young person to face the fact that the laws of physics make no concessions to inexperience or youth. The goal is to create a cognitive association between a risky action and its physical cost, thereby taking a preventive approach to curbing impulsive driving decisions.

#### **4. CONTINUITY OF LEARNING (DRIVING SCHOOL)**

The process of driver candidate training, although strictly defined by law, suffers from a series of systemic anomalies in practical application that directly jeopardize public safety. The first level of triage, the medical examination, which should serve as a rigorous barrier to eliminate psychophysically unfit candidates, is frequently reduced to a mere administrative procedure. Through superficial examinations and the neglect of detailed diagnostic procedures, a space is cleared for the conscious concealment of physical and psychological anomalies. Candidates, motivated by documentation expiration dates or the desire to acquire their license quickly, often withhold relevant health issues, which results in the issuance of medical certificates to individuals whose abilities do not meet the demands of operating a motor vehicle under complex conditions.

Following the first aid phase, the process continues through theoretical training, which in contemporary practice faces the critical phenomenon of rote learning. Instead of developing a cognitive understanding of traffic logic, ethics, and situational intelligence,

candidates primarily rely on exam question databases that they master through repetitive methods. This approach results in the mere reproduction of correct answers without a fundamental interpretation of the rules of right-of-way, the complexity of traffic flow dynamics, or the anticipation of potentially conflict-ridden situations.

Institutional pressure aimed at achieving a higher throughput of candidates, combined with the drive of driving schools to maximize profits and minimize operational costs, creates an environment where quantity is prioritized over quality. Instructors and lecturers rarely dedicate time to thoroughly explaining cause-and-effect relationships in traffic, focusing exclusively on achieving high pass rates on tests. This reduction of the educational process to the level of technical exam training results in candidates who possess theoretical information but lack situational awareness.

Consequently, we obtain drivers who recognize a sign in theory, but in practice do not understand the danger that the sign is meant to prevent. This gap between learned and applied knowledge becomes evident within the very first independent miles of driving, where a lack of understanding of system dynamics leads to wrong decisions and the endangerment of general safety. Without transforming theoretical training from a memory-based into an analytical process, driving schools remain generators of participants who view traffic as a static database of rules rather than a dynamic and high-risk system. The critical point of the process is practical training, where serious manipulations regarding the required hours of instruction have been documented. The practice of logging the legally mandated number of hours into official documentation, while in reality conducting significantly less training, results in a deficit of practical competencies. This mode of operation creates "artificially prepared" drivers who possess a license, but not the skill to operate a vehicle in crisis situations. When these structural deficiencies combine with the prior lack of traffic education throughout elementary and high school, we get a population of young drivers without a developed traffic culture or sense of

responsibility. The ultimate consequence of these cumulative failures is a statistically evident increase in traffic accidents involving precisely young drivers (Ejubović, 2026), whose inadequate training and lack of safety awareness become a fatal threat to the road network. Candidates who go through the training process via the method of mechanical memorization of tests, along with an inadequate, reduced amount of practical driving hours, generate a high degree of latent danger within the traffic system. When this deficit of knowledge and skills is combined with medical certificates issued without rigorous diagnostics, we get a driver profile operating within the system without a fundamental understanding of its rules, without a developed motor memory for vehicle operation in critical situations, and potentially with physical limitations that compromise their reaction. From an engineering and forensic standpoint, this problem becomes visible only retrospectively—that is, after a traffic accident occurs. A forensic traffic expert, when analyzing the circumstances of an event, starts from the assumption that the participant is psychophysically healthy, adequately trained, and legally capable of operating a vehicle, as mandated by the official documentation (driver's license and medical report). However, the expert analysis reveals flawed judgment and inadequate actions that are a direct byproduct of poor training. The expert sees a technical error, an inadequate braking reaction, or a misjudgment of another vehicle's speed, whereas the true cause of that error remains deeply hidden within a superficial system of education and certification. This creates a closed loop in which institutions produce unsafe drivers, and the traffic engineering profession deals with the consequences of their mistakes, while the systemic cause (poor training and examination) remains outside the scope of direct accountability.

## CONCLUSION

The analysis of the current state of traffic safety in Bosnia and Herzegovina indicates that the root of the high risk levels and fatal consequences on the road network does not lie exclusively in infrastructural deficiencies, but rather in a deep

deficit of traffic culture and systemic failures in education. Shifting from a reactive to a proactive safety model requires a radical reform in the educational approach, which treats traffic ethics as a lifelong process rather than an administrative hurdle prior to reaching the age of majority.

In early childhood, physiological and cognitive limitations such as "tunnel vision" and inadequate spatial perception must be compensated for by engineering protective zones and intensive pedagogical training. During adolescence, proactive education supported by forensic evidence and the experience of accident reconstruction experts must serve as a psychological corrective for the natural inclination toward risk-taking and social validation. Finally, the driver certification process in driving schools must be freed from profit-oriented practices, superficial medical examinations, and rote learning, ensuring that a driver's license is not just a formal document, but a genuine confirmation of competence and responsibility.

In conclusion, as long as the system produces drivers who are "capable" only on paper, the traffic engineering profession and forensic experts will deal exclusively with managing the consequences, while the root causes remain untouched. The integration of traffic culture into all levels of the educational system is the only sustainable way toward creating a safe environment where traffic rules become a reflex and human life becomes the ultimate priority. Engineering solutions and legal regulations reach their full potential only when supported by an educated and conscious individual.

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<https://www.apollohospitals.com/hr/symptoms/tunnel-vision>

<https://www.unicef.org/croatia/tinejdzeri-i-rizicno-ponasanje>

# TRANSFORMATION OF CONVENTIONAL ROAD INFRASTRUCTURE INTO INTELLIGENT ROADS –TECHNOLOGICAL FRAMEWORK AND FUNCTIONALITIES

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intelligent roadways, ITS (Intelligent Transport Systems), road safety, communication, sustainable mobility, digital transformation.

## Abstract

*This paper explores the transformation of conventional road infrastructure into intelligent roadways through the lens of integrating modern information, communication, and cybernetic systems. The research focuses on the technological framework of Intelligent Transport Systems (ITS), structured through data acquisition layers, communication protocols, and centralized management. Key functionalities are analyzed in depth, ranging from advanced traffic flow analytics and automatic incident detection to dynamic user information systems. The study evaluates the multidisciplinary benefits of implementation, emphasizing economic efficiency through congestion mitigation, environmental sustainability via reduced greenhouse gas emissions, and the primary safety imperative directed toward achieving the "Vision Zero" strategy. Special emphasis is placed on regulatory harmonization with Directive 2010/40/EU and the Transport Strategy of the Federation of Bosnia and Herzegovina, defining the perspectives for the development of cooperative systems within the domestic road network. In conclusion, intelligent roadways are recognized as an essential foundation for creating a safer and more economically efficient transport ecosystem, where the synergy between driver, vehicle, and infrastructure redefines modern mobility.*

JEL classification: R41, O33, K23



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# 1. INTRODUCTION

Road infrastructure, in the form we know it within the framework of contemporary engineering, is currently at a critical turning point of a complex evolutionary process that will fundamentally redefine its foundational function, architecture, and operational significance in modern society. Future development, design, and exploitation of roadways can no longer be viewed partially and exclusively through the traditional prism of construction expansion, asphalt works, and the physical expansion of the geometric parameters of the road network. The contemporary approach primarily implies a deep, multidimensional transformation of the entire transport system through the systemic integration of advanced information, communication, sensor, and cybernetic (ICT) technologies. In parallel with the process of designing new capacities, a key challenge and strategic priority is the systemic, phased upgrade and reconstruction of the existing, conventional road network. Due to pronounced technological obsolescence, a chronic deficit of modern control components, and inadequate throughput capacity, the existing infrastructure very often generates permanent bottlenecks and congestion. This directly causes a drastic drop in efficiency within modern transport and logistical flows, prolonged travel times, and a progressive increase in the total external and operational costs of transport entities, while simultaneously compromising the ecological integrity and the level of safety of the traffic system.

The purpose of this paper is reflected in a detailed theoretical deconstruction, systematic analysis, and scientific valorization of the complex concept of an intelligent roadway ("smart road"), along with a comprehensive critical review of contemporary engineering solutions and sophisticated execution methodologies that form the operational backbone of this system.

A special scientific and engineering emphasis will be placed on establishing an interoperable, real-time connection within the triangle formed by the three fundamental pillars of contemporary traffic: the driver as the cognitive decision-making

center, the vehicle as the advanced technological subject, and the roadway as the intelligent infrastructural environment. This research aims to explain how such a synergy, supported by cooperative communication systems, can transform traffic from a reactive into a proactive system capable of predicting incidents, optimizing throughput, and minimizing ecological degradation, thereby directly contributing to the global goals of sustainable mobility.

# 2. TECHNOLOGICAL FRAMEWORK AND FUNCTIONALITIES OF INTELLIGENT ROADWAYS

In contemporary science and traffic engineering, an intelligent roadway is defined as a complex, highly integrated cyber-physical system in which conventional, static road infrastructure is systematically upgraded and infused with advanced information, telecommunication, and computing techniques. The primary goal of this technological synergy is reflected in the radical transformation of a classical, passive infrastructural object into an intelligent and highly dynamic environment. These operations primarily encompass real-time collection, processing, and distribution of critical information to end users, proactive and adaptive management of traffic flow capacity and speeds, as well as the complete automation of safety and emergency protocols. The aforementioned processes are realized through the implementation of specialized software applications, computational decision-making algorithms, and robust control subsystems, which directly minimize the possibility of human error, optimize the throughput capacity of the roadway, and raise the level of service to its technological maximum. The backbone of an intelligent roadway consists of the ITS (Intelligent Transportation System) information system, which can be divided into three key hierarchical levels.:

Data Acquisition Layer,

This segment of the intelligent roadway architecture encompasses a complex, highly distributed network of advanced peripheral units and authoritative hardware components, whose primary role is the permanent and non-invasive acquisition of data from the field. This sophisticated technological layer integrates a wide range of elements, including:

Piezoelectric and ultrasonic sensors,

Underground inductive loops for electromagnetic detection,

Microwave and radar speed and dimension detectors,

High-frequency LiDAR (Light Detection and Ranging) systems for precise 3D environmental scanning,

Multispectral and high-resolution cameras equipped with advanced ANPR (Automatic Number Plate Recognition) algorithms.

The aforementioned measuring and detection components perform fully automated and continuous real-time data collection on all relevant parameters of the traffic flow, primarily concerning current traffic volume (intensity), flow density, space mean speed, as well as vehicle classification and structure within traffic lanes. Parallel to traffic parameters, this network of peripheral units conducts constant monitoring and exact evaluation of the physical-mechanical condition of the pavement surface itself (detection of black ice, moisture levels, presence of water, or macro-damage), as well as microclimatic and meteorological conditions in the immediate environment of the roadway (visibility, wind gusts, air temperature, and precipitation). This creates a robust and reliable information base necessary for making strategic and operational control decisions within the broader intelligent transportation system.

Communication Subsystem,

This component of the intelligent roadway architecture represents a critical, bidirectional communication channel designed for continuous and ultra-reliable exchange of structured data between end users (encompassing conventional

vehicles, autonomous transport entities, and the drivers themselves) and the central control system of the traffic network. The aforementioned communication subsystem is designed on the principles of high redundancy and utilizes robust, standardized telecommunication protocols adapted for operation in extreme and dynamic environmental conditions. Depending on the network topology and operational requirements, this layer employs advanced hybrid solutions that integrate fixed and mobile technologies:

High-capacity wired backbone infrastructure (primarily single-mode fiber-optic networks), which serves as a backbone for transmitting mass data from peripheral nodes to the central server,

Short- and medium-range wireless communication protocols (DSRC – Dedicated Short-Range Communications), designed for direct interaction based on V2I (Vehicle-to-Infrastructure) and V2V (Vehicle-to-Vehicle) architecture,

Fifth-generation mobile networks (5G and C-V2X technologies), which provide massive connectivity and support the operation of critical real-time applications.

The implementation of such a technological stack unconditionally ensures the maximum level of integrity and cryptographic protection for the transmitted information packets, while simultaneously achieving minimal, almost negligible network latency (ultra-low latency). This is of fundamental importance for the timely broadcasting of safety warnings, dynamic traffic flow management, and the prevention of incident situations across the network.

Control Layer (Central Processing System).

This layer of the intelligent roadway architecture represents the processing and operational hub of the system, which performs continuous ingestion, mass aggregation, and advanced analytical processing of heterogeneous data collected from peripheral detection nodes. Within this computing layer, unstructured data from the system is filtered, analyzed, and converted into authoritative traffic flow parameters in real time.

Based on strictly implemented mathematical algorithms, expert decision-making systems, predictive models, and valid traffic safety regulations, this subsystem automatically generates optimal control strategies. The generated decisions and commands are reflected on the ground without delay and in real time through a feedback loop. This is realized through dynamic changes in traffic signaling regimes, primarily via Variable Message Signs (VMS) portals, adaptive traffic lights at intersections, and systems for automatic speed management and lane restrictions. In this manner, the layer ensures the maximization of the roadway's throughput capacity and minimizes the risk of incidents and secondary traffic congestion.

The essential and fundamental difference between an intelligent roadway and a conventional (Čekada, 2017), classical one lies in the cognitive ability of the system to continuously learn, evolve, and make decisions based on the synergy of historical databases and structured information collected in real time. While traditional road infrastructure relies on statically calculated capacities and fixed regulation regimes, Intelligent Transportation Systems (ITS) (Ezgeta, 2013) apply advanced methods of analytics and machine learning. This high level of automation and digital integration enables a complete paradigm shift—namely, the transition from traditional, delayed, and reactive management (which acts only after a traffic incident or congestion has already formed) to advanced, proactive, and predictive traffic flow management.

By implementing proactive management strategies, the system is capable of anticipating potential bottlenecks and fluctuations in demand before they explicitly escalate across the network. (Ezgeta, 2013) This directly and measurably optimizes key throughput and level-of-service parameters (such as flow density, lane capacity, and travel time), maximizes the degree of active and passive safety for all traffic participants, and drastically reduces environmental degradation and pollution of the immediate surroundings. This ecological benefit is a direct consequence of systematically reducing traffic congestion,

eliminating the "stop-and-go" driving phenomenon, and subsequently reducing the emission of harmful exhaust gases, soot, and greenhouse particles into agroecosystems and urban environments..

Within an automated roadway, specific subsystems are implemented whose functionalities encompass:

Advanced Traffic Flow Analytics,

Continuous measurement of intensity, vehicle classification by category, and in-depth analysis of speeds and headway between vehicles.

Video Analytics and Remote Surveillance,

The use of intelligent video surveillance for automatic incident detection and remote flow management during emergencies.

Automated payment,

Contactless payment via smart cards and on-board units (OBU), thereby eliminating delays at toll plazas.

Telecontrol and Vehicle Dimensioning Systems,

The use of lasers and light curtains (optical grids) for the automatic detection of vehicles whose dimensions violate the safety clearances of structures.

Tunnel Safety Engineering,

Integrated systems for visibility enhancement, early smoke and fire detection, and the automatic activation of fire protocols and suppression systems.

Meteorological Monitoring,

Precise telemetry of atmospheric conditions (air temperature, wind speed, precipitation) as a basis for preventive road maintenance.

Dynamic Information and Navigation,

Management of variable message signs (VMS) and information boards, and the provision of real-time recommendations on optimal route choices.

Energy Management.

Intelligent regulation and adjustment of lighting depending on traffic density and ambient conditions.

Modern roadway management includes the system's ability to learn from collected data, representing a transition from reactive to proactive automation. The key functionalities defining this level of intelligence include:

Flow Monitoring,

Traffic volume measurement, vehicle classification, and in-depth analysis of traffic flow parameters.

Active Surveillance and Control,

Video surveillance with the capability for remote traffic flow management and telecontrol of vehicle dimensions using lasers and light curtains (optical grids).

Facility Safety and Security Systems (Lindov, 2008),

A special focus on tunnels through telecontrol of smoke/fire detection, automatic activation of fire suppression systems, and visibility enhancement.

Environmental Management,

Telemetry of meteorological conditions (temperature, precipitation, wind) combined with the automatic regulation of lighting.

Dynamic Communication,

Management of variable message signs (VMS) and information boards, and the provision of navigation instructions regarding currently optimal route choices.

Economic Efficiency.

Automated toll collection via "smart" cards and electronic systems.

### **3. OPERATIONAL BENEFITS AND SOCIO-ECONOMIC EVALUATION OF INTELLIGENT ROADWAY IMPLEMENTATION**

The systemic implementation of intelligent roadways generates multiple improvements within the transportation ecosystem, primarily

reflected through the optimization of traffic network performance, increased safety, and the reduction of negative external effects.

More efficient management and adequate control of traffic flows achieve a significant mitigation of traffic congestion and the elimination of critical bottlenecks. This approach directly leads to a reduction in economic losses inherent to waiting in queues and unforeseen delays. Consequently, it results in a substantial shortening of travel times for passengers and freight transport, thereby increasing the overall throughput (flow) of the infrastructure. For transport operators, the availability of real-time data enables advanced optimization of transport routes (Kiso, 2010), a reduction in operational costs, and increased reliability of logistics chains.

From a traffic safety perspective, intelligent roadways drastically reduce the "surprise factor" for drivers. Additionally, integrated SOS systems within the road infrastructure allow for near-instantaneous detection of incidents and prompt deployment of emergency services, thereby minimizing the consequences of traffic accidents.

Traffic flow optimization through ITS (Ejubović&Mališević, 2026) has a direct positive impact on environmental parameters. Reducing congestion eliminates the inefficient "stop-and-go" driving regime, which is the primary cause of increased fuel consumption and elevated emissions of harmful gases. Special importance is given to the intelligent routing and monitoring of hazardous materials (ADR) transport. This type of surveillance enables proactive action and an efficient response in the event of incidents, thereby preventing potential large-scale environmental disasters, protecting human lives, and preserving biodiversity in the immediate vicinity of roadways.

#### **4. PERSPECTIVES ON INTELLIGENT INFRASTRUCTURE DEVELOPMENT IN BIH IN THE CONTEXT OF EUROPEAN STANDARDS**

In accordance with the European regulatory framework and local strategic goals, the development of intelligent roadways in Bosnia and Herzegovina must be based on harmonization with Directive 2010/40/EU. This Directive establishes a strict framework for the coordinated deployment of Intelligent Transport Systems (ITS) (Ezgeta, 2013) across four key priority areas: the optimal use of road, traffic, and travel data in real time; the continuity of traffic and freight management services on international borders; the application of ITS road safety and security applications; and the technological linking of vehicles with the transport infrastructure (V2I)(Ezgeta,2013). The EU places a special focus on priority actions such as the interoperable eCall system for automated accident notification, information services for safe and secure parking places for trucks and commercial vehicles, and the provision of EU-wide multimodal travel information services. For these systems to be functional, they must satisfy the core principles outlined in Annex II, primarily interoperability, which enables data exchange regardless of the equipment manufacturer—and the continuity of services across the Trans-European Transport Network (TEN-T). Technical implementation relies on satellite infrastructure, such as precise positioning systems, and open in-vehicle platforms that support "plug-and-play" integration of new applications, alongside mandatory backward compatibility with existing legacy systems.

Complementary to these European aspirations, the Transport Strategy of the Federation of BiH clearly defines the need for ITS implementation as a crucial tool for drastically reducing the number of traffic accidents and raising the general level of safety. The Strategy foresees modernization through better control of traffic flows, precise recording and tracking of the transport of hazardous materials (ADR), and

continuous monitoring of vital infrastructure. The accelerated advancement of information and communication technologies opens up direct perspectives for the establishment of modern SOS networks, initially on highways and successively on other main roads. This approach enables the transition from passive to active infrastructure, where the integration of sensor networks and smart signaling ensures more efficient incident management and higher-quality information distribution to all users. In this way, the strategic goals of BiH—from economic efficiency to the protection of lives—are directly linked with the principles of energy efficiency and environmental sustainability proclaimed by European legislation.

#### **CONCLUSION**

Intelligent roadways represent not only a technological leap forward, but a fundamental paradigm of the future of transportation systems. In an era of ubiquitous automation and digital transformation, transport infrastructure is evolving from a passive physical layer into a highly connected information system. The integration of advanced ICT solutions enables the establishment of a cooperative connection between vehicles, drivers, and the infrastructure itself, resulting in incomparably more precise surveillance and more efficient management of dynamic traffic processes. Although economic sustainability and return on investment play a significant role in planning such complex systems, the primary imperative of intelligent roadway development must remain the safety aspect. The implementation of ITS technologies directly contributes to achieving "Vision Zero," because the tragic outcomes of traffic accidents, such as permanent disability or loss of life, have no market value and must not be treated as mere statistical data. Technological solutions that minimize human error and enable prompt action in crisis situations represent a moral and engineering priority of modern society. Furthermore, intelligent roadways are a key instrument in the fight against global warming and the greenhouse effect. Optimizing traffic flows directly reduces the emission of harmful pollutants, whereby the transport sector actively

contributes to decarbonization and environmental preservation. Finally, economic development and network connectivity, supported by sophisticated control centers, form the third pillar of sustainability. It can be concluded that intelligent roadways, although already implemented to a certain degree, are only at the beginning of their full developmental potential. Their further evolution is unquestionable, as they represent not just an option, but a necessity for creating a safer, greener, and economically more efficient society.

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# THE IMPACT OF GENERATIVE ARTIFICIAL INTELLIGENCE ON THE BUSINESS PROCESSES OF SMALL AND MEDIUM-SIZED ENTERPRISES

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## Abstract

*Generative artificial intelligence (GenAI) has spread into everyday business practice faster than any digital technology before it. For small and medium-sized enterprises (SMEs), which make up around 99% of all firms in the European Union, this development matters more than most: capabilities that once required specialist staff or expensive software are now available through low-cost subscriptions. This paper reviews academic literature and industry reports published between 2017 and 2026 to examine how GenAI affects core SME business processes marketing and sales, customer support, operations and administration, finance, and product development. The evidence so far points to the largest gains in content- and communication-heavy work; one field study, for instance, found that support agents using a GenAI assistant resolved about 15% more issues per hour. Adoption, however, is held back by skill shortages, concerns over output accuracy and data protection, and new obligations under the EU Artificial Intelligence Act. We conclude that GenAI substantially lowers the technological entry barrier for SMEs, but that capturing its value requires process redesign, employee training, and a risk-aware implementation strategy rather than tool purchases alone.*

JEL classification: O33, L25, M15



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# 1. INTRODUCTION

## 1.1 Background and context

When tools built on large language models became publicly available in late 2022, they spread faster than any digital technology before them [1]. Within roughly three years, generative AI reached over half of the adult population in advanced economies a faster diffusion than either the personal computer or the internet [2]. Two things set this wave apart from earlier enterprise technology. First, there is nothing to install: a browser and a subscription are enough to use state-of-the-art models. Second, the interface is ordinary language, so no specialist training is needed to get started. Both properties matter most for the firms that have historically been least able to afford specialists small and medium-sized enterprises, which form the backbone of the European economy.

## 1.2 Problem statement

SMEs have long trailed large firms in adopting advanced digital technology, mainly because of tight budgets, little in-house IT expertise, and the absence of dedicated innovation roles [3]. Generative AI could change that dynamic: it is cheap, usable through plain language, and applicable to a wide range of routine knowledge work. What is not yet clear is where exactly SMEs can capture this value in practice, and what stops them from doing so.

## 1.3 Aim and research questions

The aim of this paper is to organize what is currently known about the impact of generative AI on SME business processes. Two questions guide the analysis:

RQ1: In which business processes can SMEs derive the greatest value from generative AI?

RQ2: What are the main barriers and risks affecting GenAI adoption in SMEs?

## 1.4 Methodology

We rely on a structured review of the literature: peer-reviewed publications, working papers, and

reports by international organizations and consultancies published between 2017 and 2026. Sources were selected for relevance to two streams the technological foundations of generative AI on one side, and the economics of SME digitalization and process change on the other.

## 1.5 Paper structure

Section 2 introduces the technology. Section 3 sets out the economic framework: what SMEs are and which processes they run. Section 4, the core of the paper, analyzes the impact of GenAI on each process. Section 5 discusses opportunities, risks, and regulation, and Section 6 concludes.

# 2. GENERATIVE ARTIFICIAL INTELLIGENCE: TECHNOLOGICAL FOUNDATIONS

## 2.1 From traditional AI to generative AI

Most machine learning systems that companies have used over the past decade are discriminative: they assign inputs to categories or predict a value, as in fraud detection or demand forecasting [4]. Generative AI works differently. Instead of choosing among predefined outputs, it produces new content text, images, audio, or program code. That distinction sounds technical, but it explains why GenAI reached ordinary office work so quickly: most of what happens in an office is precisely the production of documents, messages, and other content, not numerical prediction.

## 2.2 Core concepts

Modern generative models rest on the transformer architecture introduced by Vaswani et al. [5], which made it practical to train very large neural networks on enormous text collections. When such models are trained at sufficient scale, they become what Bommasani et al. [6] call foundation models general-purpose systems that can be adapted to many different downstream tasks. Large language models such as GPT or Claude are foundation models specialized in natural language.

Three ways of adapting these models matter in practice. The simplest is prompting: the user instructs the model in plain language, with no technical setup at all. Fine-tuning goes further and retrains the model on domain-specific data. The third option, retrieval-augmented generation (RAG), connects the model to a company's own documents at the moment a question is asked, so that answers are grounded in internal knowledge rather than only in the model's general training [7]. For SMEs, RAG is arguably the most interesting of the three it delivers company-specific behavior without the cost of training a model.

### **2.3 Tools and platforms relevant to SMEs**

From an SME perspective, GenAI arrives through three channels. General-purpose assistants such as ChatGPT, Claude, Microsoft Copilot, or Google Gemini cover writing, analysis, and coding tasks for a monthly subscription. A second, quieter channel is the software firms already use: office suites, CRM systems, design tools, and accounting platforms keep adding GenAI features, which removes the adoption decision almost entirely. Finally, APIs and open-source models let firms with even modest development capacity build custom solutions a website chatbot, say, or an automated document pipeline. The practical consequence is striking: the entry cost for an SME ranges from zero to a few hundred euros per month, a fraction of any earlier enterprise technology investment. And the underlying economics keep improving the cost of running a model at the level of the original ChatGPT fell roughly 280-fold between late 2022 and late 2024 [8].

## **3. SMES AND BUSINESS PROCESSES**

### **3.1 Definition and Classification of SMEs (EU Criteria)**

Small and medium-sized enterprises (SMEs) represent a distinct category of business entities defined within the European Union according to quantitative thresholds related to employment and financial performance. The European

Commission Recommendation 2003/361/EC classifies enterprises into micro, small, and medium-sized categories based on the number of employees, annual turnover, and annual balance sheet total. Under this framework, micro-enterprises employ fewer than 10 persons and have an annual turnover or balance sheet total not exceeding EUR 2 million. Small enterprises employ fewer than 50 persons with an annual turnover or balance sheet total not exceeding EUR 10 million, while medium-sized enterprises employ fewer than 250 persons and have either an annual turnover not exceeding EUR 50 million or an annual balance sheet total not exceeding EUR 43 million [9].

The adoption of standardized SME criteria facilitates the implementation of European policies, access to financial support instruments, and comparability across Member States. It also provides a common basis for research and statistical monitoring of enterprise performance, innovation, and competitiveness within the European economy.

### **3.2 Economic Importance of SMEs**

SMEs constitute the backbone of the European economy, accounting for the overwhelming majority of businesses and making substantial contributions to employment creation and economic value generation. According to Eurostat statistics [10], SMEs represent almost all enterprises operating within the non-financial business sector in the European Union and provide employment for a significant proportion of the workforce while generating more than half of the sector's value added. Their prevalence demonstrates their central role in promoting entrepreneurship, regional development, and economic resilience.

Beyond their quantitative importance, SMEs play a crucial role in innovation and digital transformation. OECD analyses indicate that digital technologies create opportunities for productivity growth, market expansion, and improved customer engagement. However, many SMEs continue to face barriers such as limited financial resources, shortages of digital skills, inadequate technological infrastructure, and

organizational constraints that slow the adoption of advanced digital solutions. Public policies supporting digitalization, skills development, and innovation ecosystems therefore remain essential to strengthening SME competitiveness in increasingly technology-driven markets [3].

### **3.3 Overview of Core Business Processes**

Business processes encompass coordinated activities through which organizations create value and achieve strategic objectives. In SMEs, core processes typically include marketing and sales, customer support, operations and production, finance and accounting, human resource management, and research and development (R&D). Increasing digitalization and the emergence of artificial intelligence (AI) are transforming each of these functional areas.

Marketing and sales activities increasingly rely on data analytics, customer segmentation, recommendation systems, and automated communication platforms that improve targeting and customer engagement. Customer support processes benefit from AI-powered chatbots and virtual assistants capable of handling routine inquiries while enabling human employees to focus on more complex interactions. Operational functions make use of predictive analytics, intelligent automation, and process optimization tools that enhance efficiency and reduce operational costs [4].

Financial management has also been influenced by digital technologies through automated bookkeeping, fraud detection, forecasting models, and intelligent decision-support systems. In human resource management, AI applications assist recruitment, talent screening, workforce planning, and employee development by processing large volumes of information more efficiently than traditional methods. Research and development activities increasingly employ generative AI technologies to accelerate idea generation, support product innovation, and facilitate knowledge creation.

Recent literature emphasizes that digital transformation extends beyond technological adoption and often requires modifications to

organizational structures and business models. Digitalization enables SMEs to redesign value creation mechanisms, strengthen customer relationships, and improve strategic flexibility in rapidly changing markets [11], [12]. Moreover, emerging evidence suggests that larger firms generally adopt artificial intelligence more rapidly than SMEs due to greater resource availability, although targeted policy initiatives and accessible AI tools are gradually reducing this gap [13]. Generative AI, in particular, is increasingly viewed as a catalyst for business model innovation, supporting experimentation, process redesign, and new forms of value creation across organizations [14].

## **4. THE IMPACT OF GENERATIVE AI ON SME BUSINESS PROCESSES**

### **4.1 Marketing and Sales**

Generative artificial intelligence (GenAI) is significantly transforming marketing and sales activities within small and medium-sized enterprises (SMEs). By generating personalized content, automating campaign creation, analyzing customer preferences, and supporting market segmentation, GenAI enables SMEs to compete more effectively despite limited human and financial resources. Large language models and generative systems can produce advertising copy, social media posts, product descriptions, and email campaigns in a fraction of the time required by traditional methods.

McKinsey & Company [15] identifies marketing and sales among the business functions expected to capture the highest economic value from generative AI due to improvements in content creation, customer personalization, and lead generation. Similarly, Accenture [16] argues that generative AI democratizes advanced marketing capabilities by providing organizations of all sizes with access to sophisticated content production and data-driven decision-making. For SMEs, these technologies reduce operational costs while improving customer engagement and conversion rates.

## 4.2 Customer Support

Customer support has emerged as one of the most prominent areas for GenAI implementation. AI-powered conversational agents and virtual assistants can respond to customer inquiries continuously, provide multilingual assistance, summarize interactions, and recommend appropriate solutions based on historical data. Such capabilities improve service availability while reducing response times and operational costs.

Research by Davenport and Ronanki [4] demonstrates that practical AI applications often focus on automating repetitive customer interactions rather than replacing human expertise entirely. Recent global surveys further indicate that organizations increasingly deploy generative AI to enhance customer service quality, employee productivity, and knowledge management, with measurable gains in efficiency and user satisfaction [17]. These advantages are particularly valuable for SMEs that may lack dedicated customer service departments or extensive support staff.

## 4.3 Operations and Administration

Generative AI increasingly supports operational and administrative functions by automating documentation, drafting reports, summarizing meetings, managing internal communications, and assisting with workflow coordination. SMEs benefit from these capabilities because they often operate with lean organizational structures in which employees perform multiple responsibilities simultaneously.

The OECD [13] notes that AI adoption varies according to firm size, with larger organizations generally adopting advanced technologies more rapidly due to greater financial and technical resources. Nevertheless, the availability of cloud-based AI services and user-friendly generative applications is lowering adoption barriers for SMEs. Kanbach et al. [14] argue that generative AI should not merely be viewed as an efficiency tool but also as an enabler of business model innovation by reshaping organizational processes and knowledge-intensive activities.

## 4.4 Finance and Accounting

Within finance and accounting, generative AI contributes to increased efficiency through automated report generation, financial summarization, document analysis, anomaly detection, and forecasting support. AI-assisted systems can help accountants prepare narratives accompanying financial statements, review contracts, and identify irregular transactions requiring further examination.

PwC's Global AI Jobs Barometer [18] highlights that AI adoption is associated with productivity gains and changing skill requirements across professional occupations, including finance-related roles. Rather than eliminating jobs outright, AI is increasingly augmenting human expertise by reducing routine workloads and allowing professionals to concentrate on strategic analysis and decision-making. This capability is particularly important for SMEs, where finance departments are often relatively small and resource constrained.

## 4.5 Product and Software Development

Generative AI is also transforming product innovation and software development by accelerating idea generation, code production, documentation, testing, debugging, and prototype creation. Developers increasingly employ AI assistants to automate repetitive programming tasks and improve development speed while maintaining code quality.

According to BCG [19], organizations create business value from generative AI by combining automation with human creativity, enabling faster innovation cycles and improved decision-making. Bouwman et al. [11] similarly argue that digitalization reshapes SME business models by fostering new value creation mechanisms and enhancing organizational flexibility. Furthermore, Dwivedi et al. [1] emphasize that while generative AI offers substantial opportunities for innovation and productivity, organizations must also address challenges related to governance, transparency, ethics, intellectual property, and responsible implementation. Consequently, successful adoption requires both

technological capabilities and effective managerial oversight.

## **5. OPPORTUNITIES, RISKS AND IMPLEMENTATION CHALLENGES**

### **5.1 Opportunities**

The central opportunity is democratization. Tasks that used to require specialists or external agencies copywriting, translation, basic legal drafting, software prototyping, data analysis are now available through low-cost subscriptions. No previous technology wave has level the playing field between small and large firms to this degree [14]. Because GenAI is sold as a cloud service with per-user pricing, an SME can experiment for next to nothing and scale up only where value actually shows. The natural language interface matters too: it removes the dependency on scarce technical talent that the OECD [3] identifies as one of the main constraints on SME digitalization.

### **5.2 Risks and barriers**

The risks fall into four groups. The first is reliability: generative models can produce fluent but factually wrong content the well-known hallucination problem which makes unverified use risky in customer-facing, legal, and financial contexts [6]. The second is data protection. Employees may paste personal or confidential data into external AI services without thinking twice, creating exposure under the General Data Protection Regulation [20]; few SMEs have a formal AI usage policy in place. Third comes dependency: relying on a handful of foreign model providers means vendor lock-in and exposure to sudden changes in pricing or service terms. Finally, skills. The World Economic Forum [21] expects around four in ten of today's core job skills to change by 2030, and employers themselves name the skills gap as the single biggest barrier to transformation a constraint that weighs heaviest on SMEs, which have less slack for systematic training than large enterprises. Eloundou et al. [22] likewise show that exposure to LLM-driven change cuts across almost all occupations, so workforce adaptation is not optional.

### **5.3 Regulatory context: the EU Artificial Intelligence Act**

The EU Artificial Intelligence Act (Regulation (EU) 2024/1689), adopted in 2024, is the first comprehensive legal framework for AI and follows a risk-based logic [23]. For the typical SME uses discussed in this paper content creation, internal productivity, customer support the obligations are comparatively light and center on transparency: disclosing AI-generated content and telling users when they are interacting with a machine. Stricter requirements apply only to high-risk applications such as AI used in recruitment or credit decisions. The Act also contains SME-specific relief, including regulatory sandboxes and reduced documentation burdens. Even so, firms need to keep an eye on how the Act interacts with the GDPR whenever personal data flows through AI tools.

## **CONCLUSION**

This paper asked where SMEs can capture value from generative AI and what stands in their way. On the first question (RQ1), the evidence points clearly to content and communication-intensive processes: marketing and sales, customer support, and administration, where double-digit productivity gains are already documented [24]. Finance benefits in an assistive role, and product development carries the largest strategic upside up to and including new business models. On the second question (RQ2), the binding constraints turn out to be organizational rather than technological: missing skills, absent usage policies, data protection concerns, and output reliability, with the EU AI Act adding a manageable compliance layer on top.

Three practical recommendations follow. Start with low-risk, high-frequency tasks drafting, summarizing, translating where mistakes are cheap to catch. Put a simple internal AI policy in place, covering data confidentiality and mandatory human review of anything customer-facing. And treat GenAI adoption as process redesign rather than a software purchase, because the gains appear where workflows are rebuilt around the technology. The main limitation of this

review is that it rests on early-stage literature in a fast-moving field; future research should track realized, rather than projected, GenAI value in SMEs over time.

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# THE RULE OF LAW IN THE PROCESS OF EUROPEAN INTEGRATION OF BOSNIA AND HERZEGOVINA: A LEGAL CRITERION OR A POLITICAL CHALLENGE?

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## Abstract

*The rule of law is one of the key criteria that candidate countries must fulfil on the path towards membership of the European Union, while also constituting one of the Union's fundamental values. In the case of Bosnia and Herzegovina, this issue concerns not only the formal adoption of legislation and the alignment of domestic law with the EU acquis, but also the actual capacity of institutions to ensure an independent judiciary, an effective fight against organised crime and corruption, legal certainty, and the protection of fundamental rights.*

*This paper is based on the proposition that the rule of law in Bosnia and Herzegovina's European integration process is both a legal criterion and a political challenge..*

*As a legal criterion, it derives from the values of the European Union, the Copenhagen criteria, and the 14 key priorities of the European Commission. As a political challenge, it is reflected in the country's complex constitutional structure, divided competences, corruption, institutional blockades, and the insufficient implementation of reforms.*

*The aim of the paper is to highlight the difference between Bosnia and Herzegovina's formal progress in the EU accession process and the effective implementation of the rule of law in practice.*

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# 1. INTRODUCTION

The rule of law, one of the fundamental values of the European Union (hereinafter: EU) and one of the key criteria for the accession of candidate states to the Union, requires the constitution, laws and institutions to function effectively in practice, the independence of the judiciary, legal certainty, the protection of fundamental rights, and the effective fight against organised crime and corruption. In this sense, the rule of law constitutes one of the basic conditions without which a candidate state cannot demonstrate its capacity to assume and fulfil the obligations arising from EU membership.<sup>1</sup>

Bosnia and Herzegovina has passed through several phases in the process of European integration, beginning with its inclusion in the Stabilisation and Association Process (1999), the conclusion of the Stabilisation and Association Agreement (signed in 2008, entered into force in 2015) as one of the most important international legal instruments in the relations between Bosnia and Herzegovina and the European Union, the submission of the membership application (2016), followed by the granting of candidate status and the decision to open accession negotiations.

In the contemporary context, EU enlargement policy does not represent merely a technical process of admitting

new member states, but also a question of the future political, institutional and normative development of the Union itself.<sup>2</sup>

In 2019, the European Commission adopted its Opinion on the application of Bosnia and Herzegovina for EU membership. That document identified 14 key priorities which Bosnia and Herzegovina must fulfil in order to advance towards membership. These priorities relate to the areas of democracy and the functionality of institutions, the rule of law, fundamental rights, and public administration reform.<sup>3</sup>

The granting of candidate status to Bosnia and Herzegovina on 15.12.2022 and the decision of the European Council of March 2024 to open accession negotiations represent important political and institutional steps in the process of European integration.<sup>4</sup> However, the fact that the country has made progress towards EU membership does not mean that it has

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<sup>2</sup> Bourguignon, J., Demertzis, M. and Sprenger, E., "EU Enlargement: Expanding the Union and Its Potential," *Intereconomics*, vol. 57, no.4, 2022., pp. 205-208.

<sup>3</sup> European Commission, *Commission Opinion on Bosnia and Herzegovina's Application for Membership of the European Union*, COM(2019) 261 final, Brussels, 29 May 2019.

See: [https://www.dei.gov.ba/uploads/documents/prevod-misljenja-evropske-komisije-o-zahtjevu-bosne-i-hercegovine-za-clanstvo-u-evropskoj-uniji-compressed\\_1602154579.pdf](https://www.dei.gov.ba/uploads/documents/prevod-misljenja-evropske-komisije-o-zahtjevu-bosne-i-hercegovine-za-clanstvo-u-evropskoj-uniji-compressed_1602154579.pdf), (accessed 18 March 2026).

<sup>4</sup> Council of the European Union and European Council, "Bosnia and Herzegovina," Consilium, (Council of the European Union, Bosnia and Herzegovina, official page of the Consilium; European Council, Conclusions of 15.12.2022; European Council, Conclusions of the meeting of 21 and 22.3.2024. The European Council granted Bosnia and Herzegovina candidate country status in December 2022, and in March 2024 decided to open accession negotiations with Bosnia and Herzegovina.)

See: <https://www.consilium.europa.eu/hr/council-eu/> (accessed 18 March 2026).

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<sup>1</sup> Treaty on European Union, consolidated version, Article 2, which stipulates that the Union is founded on the values of respect for human dignity, freedom, democracy, equality, the rule of law and respect for human rights, including the rights of persons belonging to minorities. See also: EUR-Lex, Rule of law, glossary of European Union Law. EUR-Lex, "Rule of Law", *Glossary of European Union Law*, available at: <https://eur-lex.europa.eu/EN/legal-content/glossary/rule-of-law.html>. nit-2026;14(1)

fulfilled the criteria in the area of the rule of law. In the context of Bosnia and Herzegovina, this issue is particularly complex, since the rule of law entails not only the adoption of laws and their alignment with the EU acquis, but also their consistent application, which is often lacking in practice.

The subject of this paper is an analysis of the rule of law in the process of European integration of Bosnia and Herzegovina, with particular reference to the question of whether it should be understood as a legal criterion or a political challenge. The paper proceeds from the assumption that the rule of law is simultaneously both a legal criterion and a political challenge. As a legal criterion, it derives from EU values and legal standards, the Copenhagen criteria, and the 14 key priorities of the European Commission.

As a political challenge, it is reflected in the complex constitutional structure of the state, divided competences, institutional blockades, political influence over the judiciary, corruption, and insufficient implementation of reforms.<sup>5</sup>

The aim of the paper is to highlight the difference between the formal progress of Bosnia and Herzegovina in the EU accession process and the actual application of the principles of the rule of law in practice.

The paper will first analyze the rule of law as a fundamental value and criterion of the EU, followed by an examination of Bosnia and Herzegovina's European integration path and the significance of the European Commission's 14 key priorities. It will

then address the legal and political challenges related to strengthening the rule of law in Bosnia and Herzegovina, particularly in the areas of the judiciary, the fight against corruption, institutional dysfunction, and the weak implementation of reforms.

## **2. THE RULE OF LAW AS A FUNDAMENTAL VALUE AND CRITERION OF THE EUROPEAN UNION**

The rule of law is one of the values upon which the Union is founded, and as such occupies a special place in its legal and political order. Article 2 of the Treaty on European Union (TEU) refers to the values of respect for human dignity, freedom, democracy, equality, the rule of law, and respect for human rights, including the rights of persons belonging to minorities.<sup>6</sup> These values are common to the Member States of the Union and constitute the foundation of the political, legal, and institutional identity of the European Union.

In the context of the Union, the rule of law implies that all public authorities act within the limits of the law, in accordance with democratic values and with respect for fundamental rights.

It encompasses the principles of legality, legal certainty, the prohibition of arbitrariness on the part of the executive authorities, an independent and impartial judiciary, effective judicial protection, and equality of all before the law.<sup>7</sup> The rule of law therefore cannot be reduced to the

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<sup>5</sup> European Commission, *Bosnia and Herzegovina Report 2024*, Brussels, 30 October 2024, available at: [https://enlargement.ec.europa.eu/document/download/451db011-6779-40ea-b34b-a0eeda451746\\_en?filename=Bosnia+and+Herzegovina+Report+2024.pdf](https://enlargement.ec.europa.eu/document/download/451db011-6779-40ea-b34b-a0eeda451746_en?filename=Bosnia+and+Herzegovina+Report+2024.pdf) (20 March 2026). nit-2026;14(1)

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<sup>6</sup> *Consolidated Version of the Treaty on European Union, Official Journal of the European Union*, C 202, 7 June 2016.

<sup>7</sup> Council of Europe, European Commission for Democracy through Law-Venice Commission, *Rule of Law Checklist*, Study No. 711/2013, CDL-AD(2016)007, Strasbourg, 18 March 2016, pp. 10-11.

mere formal existence of legal norms, but requires their genuine and consistent application.

In this context, the process of European integration may also be viewed as a process of Europeanisation, that is, as the impact of European rules, standards and institutions on domestic policies, legal structures and institutional practices.

Börzel and Risse point to the so-called „top - down“ approach, which examines how European integration affects domestic policies, political processes and institutions.<sup>8</sup> Such an approach is also significant for understanding the rule of law in Bosnia and Herzegovina, as it demonstrates that European integration does not entail merely the formal harmonisation of legislation, but also the genuine transformation of domestic institutions and political practice.

What makes the concept of the rule of law particularly important is the fact that it represents a link between democracy, human rights and institutional accountability. These elements are mutually connected and interdependent, such that the rule of law constitutes a guarantee that power is not above the law, that institutions operate within the scope of their competences, and that citizens have the possibility of having their rights protected before independent bodies.

For candidate countries seeking EU membership, the rule of law represents one of the key political criteria for accession. The Copenhagen criteria, established in 1993, require that a candidate state have stable institutions guaranteeing democracy, the rule of law, human rights, and respect for and protection of

minorities.<sup>9</sup> Thereby, the rule of law was established as one of the fundamental preconditions for membership, but also as a measure of a state's genuine readiness to function within the legal and institutional framework of the EU.

When speaking of the enlargement process, the Union regards the rule of law as a substantive question of state functioning. It is not sufficient merely to adopt laws harmonised with the EU *acquis*; those laws must be implemented in practice, institutions must operate independently and accountably, and citizens must be guaranteed effective protection of their rights. For this reason, particular attention is paid in the accession process to the judiciary, the fight against corruption and organised crime, public administration and the protection of fundamental rights.

In the case of Bosnia and Herzegovina, the rule of law was particularly emphasised through the European Commission's Opinion on Bosnia and Herzegovina's application for membership of the European Union, issued in 2019. In that document, the European Commission identified 14 key priorities that Bosnia and Herzegovina must fulfil in order to advance in the accession process, with particular prominence given to questions of institutional functioning, judicial reforms, the fight against corruption and organised crime, the protection of fundamental rights and public administration reform.<sup>10</sup> It follows from the foregoing that the rule of law in the process of European integration of Bosnia and Herzegovina appears as a concrete set of reform obligations. It is, simultaneously a fundamental EU value, a legal standard

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<sup>8</sup> Börzel, T.A. and Risse, T., "Conceptualizing the Domestic Impact of Europe," in K. Featherstone and C.M. Radaelli (eds.), *The Politics of Europeanization*, Oxford University Press, Oxford, 2003, pp. 57-80.  
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<sup>9</sup> European Council, *Presidency Conclusions, Copenhagen European Council*, 21-22 June 1993, Copenhagen, 1993.

<sup>10</sup> European Commission, *Commission Opinion on Bosnia and Herzegovina's Application for Membership of the European Union*, COM(2019) 261 final, Brussels, 29 May 2019.

requiring institutions to function effectively, and an accession criterion for assessing a candidate country's capacity to assume and implement the obligations of membership.

### **3. THE EUROPEAN PATH OF BOSNIA AND HERZEGOVINA: FROM THE STABILISATION AND ASSOCIATION AGREEMENT TO THE 14 KEY PRIORITIES OF THE EUROPEAN COMMISSION**

The European path of Bosnia and Herzegovina has developed through the several stages outlined above, which demonstrate that the EU accession process is not solely a political process, but also a legal and institutional one that requires the harmonisation of legislation, the strengthening of institutions and the genuine implementation of reforms.

Of particular significance in this process is the Stabilisation and Association Agreement, which established the legal framework for relations between Bosnia and Herzegovina and the European Union. Its importance is reflected both in the formal approximation to the European Union and in the obligations relating to democracy, the rule of law, institutional stability, and the harmonisation of legislation.

The further development of the European path of Bosnia and Herzegovina has been marked by the European Commission's Opinion of 2019 and the identification of 14 key priorities, which demonstrate that Bosnia and Herzegovina's progress towards membership cannot be measured solely by formal changes in status, but also by the capacity of the state to implement genuine reforms in the areas of the rule of law, the judiciary, public administration, and the protection of fundamental rights.

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#### **3.1. The Stabilisation and Association Agreement as the Legal Framework for the European Path of Bosnia and Herzegovina**

The Stabilisation and Association Agreement (SAA) represents one of the key legal instruments in the process of Bosnia and Herzegovina's approximation to the European Union. In an earlier work on the Structure, Significance and Scope of the Stabilisation and Association Agreement, the author noted that the SAA, comprising ten chapters, serves as an integration instrument integrates Bosnia and Herzegovina into European political and economic processes, strengthens its position in the region, and contributes to the strengthening of institutions within the state. At the same time, in terms of its content, the SAA points to the need to fulfil the criteria for membership, in particular the legal criterion, the adoption and implementation of the EU acquis, and the economic criterion.<sup>11</sup> The Agreement was signed on 16 June 2008 in Luxembourg and entered into force on 1 June 2015.<sup>12</sup>

Pursuant to Article 1, paragraph 2 of the SAA, one of the objectives of the association is to support the efforts of Bosnia and Herzegovina in strengthening democracy and the rule of law. In addition, the Agreement aims to contribute to the

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<sup>11</sup> Burina, E., "Struktura, značaj i doseg Sporazuma o stabilizaciji i pridruživanju," *Revija za pravo i ekonomiju*, god. 24, br.2., Pravni fakultet Univerziteta "Džemal Bijedić" u Mostaru, Mostar, 2023, pp. 378.

<sup>12</sup> *Stabilisation and Association Agreement between the European Communities and Their Member States, of the One Part, and Bosnia and Herzegovina, of the Other Part*, Directorate for European Integration of Bosnia and Herzegovina, signed on 16.6.2008, entered into force on 1.6.2015. See: Direkcija za europske integracije BiH, Sporazum o stabilizaciji i pridruživanju: <https://www.dei.gov.ba/bs/page-stabilization-agreement> (accessed 10 April 2026).

political, economic, and institutional stability of Bosnia and Herzegovina, to the development of political dialogue, to the harmonisation of legislation with that of the European Union, and to the development of regional cooperation.<sup>13</sup> Thus, already within the framework of the SAA, the rule of law was established as one of the important elements of the European path of Bosnia and Herzegovina.

Although the normative framework of the SAA has been established, practice reveals a significant gap between the obligations assumed and their implementation. The European integration process has frequently been slowed by political fragmentation, weak institutional capacities, and insufficient effectiveness in implementing the commitments undertaken. As Rizvanović notes, the SAA is undoubtedly crucial for Bosnia and Herzegovina's progress towards EU membership, but its implementation requires political will, institutional stability, and the alignment of legislative and administrative capacities.<sup>14</sup> Moreover, effective enforcement of the law is also necessary in order to achieve balanced and sustainable progress towards EU membership.<sup>15</sup>

The SAA is therefore not merely a formal

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<sup>13</sup> *Stabilisation and Association Agreement between the European Communities and their Member States, of the One Part, and Bosnia and Herzegovina, of the Other Part*, Article 1, paragraph 2. See: [https://www.dei.gov.ba/uploads/documents/sporazu-m-o-stabilizaciji-i-pridruzivanju-izmedu-eu-i-bosne-i-hercegovine-hrvatski-jezik\\_1604320257.pdf](https://www.dei.gov.ba/uploads/documents/sporazu-m-o-stabilizaciji-i-pridruzivanju-izmedu-eu-i-bosne-i-hercegovine-hrvatski-jezik_1604320257.pdf) (accessed 10 April 2026).

<sup>14</sup> Rizvanović, E. and Batinović, Ž. „Struktura i trgovinski učinci Sporazuma o stabilizaciji i pridruživanju,” *Revija za pravo i ekonomiju*, god.18. br.2, Pravni fakultet Univerziteta „Džemal Bijedić“ u Mostaru, Mostar, 2018, pp.40.

<sup>15</sup> Rizvanović, E. “Bosna i Hercegovina - od stabilizacije do pridruživanja,” *Revija za pravo i ekonomiju*, god. 20. br. 2, Pravni fakultet Univerziteta “Džemal Bijedić“ u Mostaru, Mostar, 2019. nit-2026;14(1)

legal framework for relations between Bosnia and Herzegovina and the European Union, but also an instrument that demonstrates how necessary and important the genuine implementation of assumed obligations is for the EU accession process. Through its application, it is confirmed that the rule of law in Bosnia and Herzegovina is not solely a legal criterion, but also a political and institutional challenge.

### **3.2. The European Commission's Opinion of 2019 and the 14 Key Priorities**

Following the entry into force of the SAA, the next important phase in the European integration process was Bosnia and Herzegovina's submission of its application for membership of the European Union. The application was submitted on 15 February 2016, in accordance with Article 49 of the TEU. This opened a new phase in relations between Bosnia and Herzegovina and the European Union, in which the country was expected to demonstrate its capacity to fulfil the political, economic, legal<sup>16</sup> and institutional criteria for membership.

On 29 May 2019, the European Commission adopted its Opinion on Bosnia and Herzegovina's application for membership of the European Union and identified 14 key priorities that must be met in order for Bosnia and Herzegovina to advance in the accession process. These priorities relate to the areas of democracy and the functionality of institutions, the rule of law, fundamental rights, and public administration reform.<sup>17</sup> They demonstrate that Bosnia and Herzegovina's European

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<sup>16</sup> Burina, E., “Struktura, značaj i doseg Sporazuma o stabilizaciji i pridruživanju,” pp. 381.

<sup>17</sup> European Commission, Commission Opinion on Bosnia and Herzegovina's Application for Membership of the European Union, COM(2019) 261 final, Brussels, 29 May 2019.

integration depends not only on the formal adoption of legislation and the alignment of domestic law with the EU *acquis*, but also on the effective implementation of reforms.

A particularly prominent place in the Commission's Opinion is occupied by the issue of the rule of law, which appears not merely as a general principle but also as a concrete set of reform obligations. In this way, European Commission made it clear that further progress towards membership depends on substantive reform rather than merely formal compliance with the conditions.

The Opinion of the European Commission made it unequivocally clear that serious reforms are required for Bosnia and Herzegovina to achieve sustainable progress towards membership of the Union.<sup>18</sup> It is precisely for this reason that the 14 key priorities represent the link between formal political progress and the genuine institutional transformation of the state. They demonstrate that candidate status and the decision to open accession negotiations cannot substitute for the actual implementation of reforms in the areas of the rule of law, the judiciary, the fight against corruption, public administration, and the protection of fundamental rights.

The granting of candidate status to Bosnia and Herzegovina on 15 December 2022 represented an important political step and a confirmation of the country's European perspective, as well as its aspiration to become an EU Member State. However, candidate status does not mean that all requirements in the area of the rule of law have been fulfilled. The European Council, in March 2024, adopted a decision to open accession negotiations with Bosnia and Herzegovina, thereby initiating a new phase in relations between Bosnia and Herzegovina and the European

Union.<sup>19</sup> Further progress will depend on the capacity of domestic institutions to consistently implement the commitments undertaken.

#### **4. LEGAL AND INSTITUTIONAL CHALLENGES OF THE RULE OF LAW IN BOSNIA AND HERZEGOVINA**

The rule of law in Bosnia and Herzegovina should not be viewed solely as a formal legal criterion, but also as a matter of the state's genuine institutional capacity to implement laws, protect fundamental rights, and ensure the independent functioning of the judiciary. In its 2019 Opinion, the European Commission clearly indicated that Bosnia and Herzegovina must improve its legislative and institutional framework in order to fulfil the 14 key priorities, particularly in the areas of democracy, the rule of law, fundamental rights, and public administration.<sup>20</sup>

In the author's earlier work, it was highlighted that European integration affects national legal sovereignty through the acceptance of the European Union's *acquis*, the alignment of domestic legislation, and the adaptation of national institutions to the supranational legal framework.<sup>21</sup>

One of the fundamental challenges is the

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<sup>19</sup>Council of the European Union and European Council, "Bosnia and Herzegovina," Consilium, available at: <https://www.consilium.europa.eu/hr/policies/bosnia-herzegovina/> (accessed 15 April 2026).

<sup>20</sup> European Commission, *Commission Opinion on Bosnia and Herzegovina's Application for Membership of the European Union*, COM(2019) 261 final, Brussels, 29 May 2019.

<sup>21</sup> Burina, E., "Analiza pravnih i političkih područja uticaja Europske unije na nacionalni pravni suverenitet," *Godišnjak Pravnog fakulteta Univerziteta „Džemal Bijedić” u Mostaru*, god. VII, br.7, Mostar, 2023., pp. 124-129.

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<sup>18</sup> Ibidem.  
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complex constitutional structure of Bosnia and Herzegovina. The country's multilayered system of government frequently hampers the harmonisation of legislation with the EU acquis, as well as the consistent application of regulations already adopted. For this reason, institutions must be functional and operate in a responsible and coordinated manner.

A particular problem is the functioning of the judiciary. In its 2024 Report on Bosnia and Herzegovina, the European Commission emphasises that an effective, independent, high-quality and efficient judicial system is of great importance for the rule of law, as well as for the effective fight against corruption.<sup>22</sup> The poor functioning of the judicial system has a negative impact on the protection of citizens' rights and on public trust in institutions. This is the reason why judicial reform is crucial in the process of accession to the Union.

Another important challenge concerns the fight against corruption and organised crime. The European Commission assesses that Bosnia and Herzegovina is still between an early stage of preparation and some level of preparation in the fight against corruption, whilst results with regard to investigations, prosecutions and convictions in high-level corruption cases remain insufficient.<sup>23</sup> Similar problems exist in the fight against organised crime, where inadequate coordination among institutions and the lack of harmonisation of regulations impede the effective action of the competent authorities.<sup>24</sup>

A significant challenge is also posed by public administration reform, from which professionalism, depoliticization and the capacity to implement reforms are

expected. However, the European Commission notes that Bosnia and Herzegovina is still at an early stage of preparation, and that it is necessary to ensure a professional civil service and a coordinated approach to public policy-making at the country-wide level.<sup>25</sup>

It may be concluded that the rule of law in Bosnia and Herzegovina cannot be reduced to the formal adoption of legislation, and that its true value is measured through the independence of the judiciary, the effectiveness of institutions, the fight against corruption, legal certainty and the capacity of the public administration to implement reforms. It is precisely for these reasons that the rule of law in Bosnia and Herzegovina remains both a legal criterion of European integration and a political-institutional challenge.

## **5. THE IMPLEMENTATION OF REFORMS AS THE KEY TEST OF THE RULE OF LAW**

When speaking of the process of European integration of Bosnia and Herzegovina, the question of formal and substantive progress along that path arises in particular. Formal progress is reflected in the adoption of laws, strategies and institutional documents, whilst substantive progress is measured by the application of what has been adopted in practice. It is here that the rule of law becomes apparent not only as a legal criterion but also as a matter of political will, institutional accountability and state effectiveness of the state.

In its Opinion of 2019, the European Commission clearly linked further progress by Bosnia and Herzegovina to the fulfilment of 14 key priorities, which require concrete results in the areas of the judiciary, the fight against corruption and

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<sup>22</sup> European Commission, *Bosnia and Herzegovina Report 2024*, Commission Staff Working Document, SWD(2024) 691 final, Brussels, 30 October 2024. pp.28.

<sup>23</sup> *Ibidem*, pp.33-35.

<sup>24</sup> *Ibidem*, pp. 44.46.  
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<sup>25</sup> *Ibidem*, pp.25-26.

organized crime, the protection of fundamental rights and public administration reform.<sup>26</sup> The rule of law thus becomes a measure of the state's capacity not merely to formally accept the obligations it has undertaken, but to genuinely implement them.

An independent, impartial and efficient judiciary represents the fundamental prerequisite for the protection of citizens' rights and legal certainty. Without a functional judiciary, one cannot speak of an effective fight against corruption, equality before the law, or citizens' trust in institutions. For this reason, judicial reform remains one of the most important indicators of the genuine application of the rule of law in Bosnia and Herzegovina.<sup>27</sup>

How important the actual implementation of reforms is can be seen in the fight against corruption and organized crime. The adoption of laws and strategies cannot produce the expected effect if there are no concrete results in the form of effective investigations, indictments and final judgments, particularly in high-level corruption cases.

The European Commission, in its reports on Bosnia and Herzegovina, consistently points out that results in this area remain limited, which confirms the existence of a gap between formal obligations and their practical realisation.<sup>28</sup>

A similar problem arises in the area of public administration. If it is not efficient, coordinated and depoliticized, a standard that Bosnia and Herzegovina's public administration currently meets only to a very limited extent - the European

integration process remains slow and reform obligations are not implemented as they should be, either in the manner or to the extent required.

On the basis of the foregoing, the rule of law in Bosnia and Herzegovina cannot be assessed solely by the number of laws or decisions adopted. The value of the rule of law ought to be reflected in the capacity of institutions to apply laws, protect citizens' rights, prosecute and prevent corruption, and ensure legal certainty. Therefore, the implementation of reforms constitutes a test of the rule of law and confirms the central thesis of this paper, namely that in the process of European integration of Bosnia and Herzegovina the rule of law is a legal criterion, yet its realisation in practice emerges as a political and institutional challenge.

## CONCLUSION

On the basis of all of the foregoing, it is concluded that the rule of law occupies a special place in the process of European integration of Bosnia and Herzegovina. It is not merely one of the formal conditions that a candidate state must fulfil on the path towards membership of the European Union, but rather a genuine indicator of the functioning of the state, its institutions and its legal system.

Starting from the introductory considerations, it is evident that Bosnia and Herzegovina has achieved a degree of formal progress towards membership of the Union, reflected in its inclusion in the Stabilisation and Association Process, the signing and entry into force of the Stabilisation and Association Agreement, the submission of the membership application, the granting of candidate status, and the decision to open accession negotiations. However, such formal progress does not necessarily mean that the rule-of-law criteria have been fulfilled in practice.

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<sup>26</sup> European Commission, *Commission Opinion on Bosnia and Herzegovina's Application for Membership of the European Union*, COM(2019) 261 final, Brussels, 29.5.2019., pp. 14-15.

<sup>27</sup> European Commission, *Bosnia and Herzegovina Report 2024*, Commission Staff Working Document, SWD(2024) 691 final, Brussels, 30 October 2024, pp. 28.

<sup>28</sup> *Ibidem*, pp. 33-35 and 44-46.  
nit-2026;14(1)

The analysis of the rule of law, as a fundamental value of the European Union, has demonstrated that this principle cannot be assessed solely on the basis of whether legislation formally exists and that it requires the consistent and effective application of legal norms in practice. The rule of law entails legality, legal certainty, an independent judiciary, the protection of fundamental rights, and equality before the law.

An examination of Bosnia and Herzegovina's European path reveals that the Stabilisation and Association Agreement played an important role in establishing the legal framework governing relations between Bosnia and Herzegovina and the European Union. The Agreement laid the foundation for political dialogue, regional cooperation, legislative harmonisation, and the strengthening of institutions. The legal framework, in itself, is insufficient if the obligations undertaken are not implemented. For this reason, the 14 key priorities of the European Commission are of great significance, as they demonstrate that further progress by Bosnia and Herzegovina depends on genuine reforms.

The legal and institutional challenges to the rule of law in Bosnia and Herzegovina have proved to be particularly significant. The constitutional structure of the state, multiple levels of governance, insufficient inter-institutional cooperation, problems within the judiciary, corruption, organised crime, and an inefficient and politicised public administration in the process of European integration. Bosnia and Herzegovina must build effective institutions capable of implementing laws not only *de iure*, but also *de facto*.

The rule of law in the process of European integration of Bosnia and Herzegovina constitutes a legal criterion, as it derives from EU values, the Copenhagen criteria, the Stabilisation and Association Agreement, and the 14 key priorities of the

European Commission. It is also a political and institutional challenge, since its *de facto* application depends on political will, the functionality of institutions, the independence of the judiciary, and the state's readiness and commitment to implement reforms.

The genuine readiness of Bosnia and Herzegovina for membership in the European Union is measured by the state's capacity to ensure the rule of law in practice. Only when laws are consistently applied, institutions function effectively, the judiciary operates independently, and corruption is effectively investigated and prosecuted can the rule of law become a genuine principle of governance rather than merely a condition for EU accession.

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