Școala Națională de Studii Politice și Administrative
Facultatea de Administrație Publică
Smart-EDU Hub

Smart Urban Development
Dezvoltare Urbană Inteligentă

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PRO UNIVERSITARIA 2025 BUCUREŞTI
SCRD Book Series

Editat de **Pro Universitaria SRL**, editură cu prestigiu recunoscut.

Editura **Pro Universitaria** este acreditată CNCS în domeniul Științelor Umaniste și CNATDCU (lista A2-Panel 4) în domeniul Științelor Sociale.

Descrierea CIP a Bibliotecii Naţionale a României
Smart urban development = Dezvoltare urbană inteligentă / coord.:
Cătălin Vrabie. - Bucureşti : Pro Universitaria, 2025
Conţine bibliografie
ISBN 978-606-26-2131-5

I. Vrabie, Cătălin (coord.)

711
004

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www.prouniversitaria.ro
Editura Pro Universitaria

Librăria UJmag:
tel.: 0733.673.555; 021.312.22.21
e-mail: comenzi@ujmag.ro
www.ujmag.ro
Ujmag.ro

CUPRINS

Smart mobility: urban mobility concept in EU policies. Gentle Electric: The "green brand" from Craiova, Romania

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Abstract
The paper presents the work carried out over the last 5 years in the development of a project that has focused both on the research and production of electric two-wheeled vehicles (electric scooters, electric bicycles, electric scooters, chairs for disabled people) and on the building of the necessary infrastructure for their production. The paper opens with a presentation of the current context of mobility, the objectives and trends towards greener, low or zero emission mobility. In the era of growing environmental and sustainability concerns, electric mobility is an essential pillar in the transition towards a cleaner and more sustainable future.

Keywords: transport, mobility, green energy, emissions.

1. Introduction
The transition to greener mobility in the period to come (2025 -2030 - 2050) aims to bring up to date and make available to the citizens of the European Union and Europe a current, accessible, accesible and affordable transport system, even in the most socio-economically challenged areas.

The transport sector will accelerate the transformation of new technologies into the technologies of the future (the trend is towards zero carbon).

By 2050, transport emissions are expected to be reduced by 90% to achieve climate neutrality.

The European Commission is advocating that all EU countries commit funding to meet ambitious targets to reduce carbon emissions from cars and trucks, and to bring electric means of transport into urban planning.

The motto for 2025 - 2030 (2050) is: cleaner cars, cleaner air.

Today, EU recommendations and new technologies aim to reduce carbon emissions (from cars, trucks, motorcycles, ships, boats, including airplanes) up to 55% by 2030, and new car models from all sources will aim for zero emissions by 2035.

Developing the market (in the European Union) for zero (or low) emission cars are targets for manufacturers, but also linking affordability with the income and possibilities of low to middle income citizens (countries with average income below 1000 euros).

The European Union through the European Commission is proposing infrastructure targets for alternative fuels (e.g. for electricity and hydrogen). These are essential measures for citizens who will be willing to invest in cleaner vehicles.

2. Results and discussions [1]

In 2026, road transport enters the emissions trading market, which means there will be a price for pollution, stimulating the use of cleaner fuels and encouraging investment in clean technologies.

Ensuring sustainable mobility and measures to offset the climate footprint are priorities in all EU policies. Including the aviation sector is subject to clear and sustainable carbon footprint measures by 2030-2035 (promoting sustainable fuels in the aviation sector), with airplanes required to use blended fuels for all departures from EU airports.

The European Commission is requiring major airports to ensure that airplanes have the possibility to power aircraft at all gates.

Action has also been taken in the maritime, inland waterway and trans-ocean sectors on new rules imposed by the Commission until 2030-2035.

Carbon pricing measures in the maritime sector encourage the use of sustainable fuels for all ships leaving or calling at an EU port. Ships, irrespective of their origin, that do not comply with these limits will have to pay a dissuasive financial penalty.

The European Commission will set targets for major core ports to be obliged to provide ships with shore-side electricity, which would reduce the use of polluting fuels that affect local air quality.

All industrial sectors in the European Union will move to promote the Green Transition, an opportunity in European industry by creating markets for environmentally clean technologies and products.

Strengthening carbon pricing in industry is another measure that will greatly encourage investment and innovation. The emergence of a fund for innovation and restructuring is being strengthened.

Value chains in sectors such as energy and transport, construction and renovation, will help create more local and well-paid sustainable jobs across Europe, linked to investment in a

low-carbon economy, with the focus on green recovery. More than 35 million buildings in the EU are expected to undergo renovation, targeting cities with high pollution.

Over 100 million additional construction jobs will be created.

Renewable energy is driving a green economy with new job creation opportunities in all sectors. Increased energy efficiency in buildings will increase construction jobs and the demand for local labor. EU cities, small or large, will become hubs for the deployment of new green technologies with increased demands towards smart cities (smart city - city in 15 minutes) with opportunities to develop sustainable and sustainable education for future generations of the third millennium.

It is to be recognized that every household is expected to have access to a motivated and affordable renewable (sustainable) energy source by 2030.

Today we have a statistic from the European Union showing that around 6 million electric cars were sold between 2020-2024, far exceeding forecasts, including those of the automotive industry within the European Union. More than 30 million zero emission cars are expected to be on Europe's roads by 2030.

The EU's ambitious targets, especially on climate, and industry's efforts to reduce carbon emissions will also bring tough policies to tackle unfair competition from abroad.

The commission is proposing a mechanism to ensure that companies that pollute in the EU have to pay a price for carbon emissions from and when they are based in countries with less stringent climate regulations.

EU-wide energy savings targets are binding, aiming for an overall reduction of 36% by 2030.

The energy taxation system must also support the green transition by providing incentives to match.

Aligning the minimum tax rates applied in the thermal energy and transport sectors will mitigate the social impact and in particular support vulnerable citizens.

The European Commission also proposes to eliminate tax exemptions and apply reduced taxes to encourage the use of fossil fuels (aviation, maritime sector).

3. Conclusions

The "Ecological Initiative and Sustainable Development Group" (G.I.E.E.D.D) Foundation together with the academic community - Academy of Agricultural and Forest Sciences Bucharest, Romanian Academy, University of Agricultural Sciences and Veterinary Medicine Bucharest, University of Craiova, small and medium enterprises we have generated hundreds of events that launched the concept of urban mobility.

Also, through the work undertaken and our long-standing research, we managed to set up in Craiova the foundations of a modern factory that received European funding under a competitiveness and urban mobility program. Gentle Electric, founded in 2017, has started by developing a full range of electric vehicles to meet the needs of any person.

Electric vehicles have been created, relying on modern production, assembly and service facilities, utilizing the latest technology.

Gentle Electric vehicles are today able to compete in the EU and global markets.

The city of Craiova is home to Gentle Electric's capacity from scratch with its own funds and European funding (around €5 million, rising to €21 million).

We have succeeded in bringing to the market, in the 14 to 50 age segment, the electric scooter with a unique braking energy generation system.

The GT series scooters are now compatible with a smart app that will improve the driving experience as well as comfort and safety.

Urban walking nowadays allows users to save time and money, and especially for recreational purposes, a movement that emphasizes smart health.

The speed of a scooter made in Romania can be adjusted (14-35 km/h) and has a range of up to 40 km. The motors have a peak power of about 700W and are powered by a 48V, 7.8AH li-ion battery.

We have initiated European Union legislation to regulate electric scooters in several countries, as manufacturers of electric scooters we have adapted on the fly to the needs of each market and today we have electric bikes, scooters and electric motors for various other prototypes in production and in the pipeline.

Gentle Electric's vision of urban mobility focuses on flexibility.

We want to provide every person with a safe and inexpensive transportation solution that is also kind to the environment (no pollution).

We also commercialize our patented Gentle Electric Fat Bike folding electric bikes with multiple pedal assist steps and all-electric driving options, including adapting new wheel and rim types. The Gentle Electric Fat Bike V2 V2 reaches a maximum speed of 25 km/h, 50 km range, 250W peak motor power, 36V 12.5AH Li-Ion battery.

The company, today has embarked on a long journey in providing sustainable solutions on both the production of electricity and the commercialization of eco-friendly vehicles.
The activity also includes the simplified application side of projects developing photovoltaic systems and sustainable electric vehicles.

We are committed to building a green future, which is why we take the decision to encourage everyone who opts for our services to choose the right solutions.

Energy autonomy is at the core of our business, completing our long line of green energy research and innovation.

Acknowledgements
The study was conducted by The "Ecological Initiative and Sustainable Development Group" Foundation with the support of Gentle Electric Solar SRL with the purpose of developing a market segment that will improve mobiliy and contribute to an easier transition to a greener economy.

References

[1] "Project Construction of industrial hall and equipping with the necessary equipment for the production of vehicles powered by brushless electric motors powered by lithium-ion batteries for transport of persons - Gentle Electric," *implemented within the Sectoral Operational Program "Increasing Economic Competitiveness", at the level of Construct* Cluster *Oltenia, The overall objective of the project was to increase the competitiveness, at European level,* 2014-2016.

TEN-T digital transport corridors in the Republic of Moldova: achievements and perspectives

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Abstract
This article examines the European practice of establishing connections to the Trans-European Transport Network (TEN-T) and digital transport corridors, as well as the potential for cross-border paperless operations in e-logistics operations in the Republic of Moldova. The necessity for improvement in the methodological and innovative approaches to e-government at the regional and local level is discussed, as well as the need for unification of national e-commerce and logistics systems of candidate countries in accordance with the INSPIRE Directive. The EU-Ukraine Solidarity Lanes initiative plays an important role in facilitating recovery and integration of Ukraine and the Republic of Moldova into the EU single market. In order to achieve this, there is a clear need for the modernization of cross-border digital services. The significance of "living labs" in the integration of transport networks between the border sections of regional territories comprising the physical pan-European transport corridor is emphasised. In accordance with the "National Digital Transformation Strategy until 2030" and "National Strategy for Smart Specialisation by 2030," a special focus is placed on the utilisation of local innovative infrastructure for the efficient integration of local communities in the EU Digital Single Market.

Keywords: digital transport corridors, innovation investments, EU Digital Single Market, Living Lab, Solidarity lanes.

1. Introduction
The Instrument for Interregional Innovation Investments (I3) [1] is approach of financing thematic areas in accordance with the regulations of the European Regional Development Fund (ERDF) [2]. In the Republic of Moldova, this function is managed by the National Fund for Regional and Local Development, which aims to stimulate the development of European value chains by mobilising innovation ecosystems to scale up and commercialise inter-regional innovation projects.

The I3 work program aims to promote innovation through smart specialisation and inter-regional cooperation. I3 supports closer inter-regional investment cooperation and builds sustainable linkages by bringing together regional ecosystems into common smart specialisation areas vital for accelerating market uptake of research results and fostering innovation. The structure of the I3 tool consists of three thematic areas, as shown in Figure 1.

Fig. 1. I3 thematic areas and strands [1]

Following [3], Strand 1 targets mature partnerships to help them accelerate market uptake and scale-up of innovative solutions in shared smart specialisation priority areas, as well as to develop a portfolio of investment projects.

Strand 2a focuses on increasing the capacity of regional innovation ecosystems in less developed regions to participate in global value chains, as well as the capacity to participate in partnerships with other regions.

Strand 2b projects refer to the concrete experimentation of new approaches, solutions and good practices to engage in interregional innovation processes mobilising ecosystems and in particular SMEs.

Within the framework of Moldova's participation in the Danube Interregional Cooperation Program [4], there is an intensive convergence of technological, social and political trends, such as: connectivity, automation, electrification, blockchain, new vehicle concepts, a new attitude of society towards provision and consumption. transport services, new policies to combat and/or adapt to climate change. These trends offer a unique opportunity to rethink transport systems and make them safer, cleaner, more efficient and reliable over the next few decades.

Following the full-scale invasion of Ukraine by Russia and the subsequent blockade of Ukrainian seaports, the Ukrainian government is facing significant challenges in facilitating the export of its products and the import of necessary resources. In response to this crisis, the EU has implemented a series of measures collectively referred to as "Solidarity Lanes." [5] These initiatives aim to ensure the uninterrupted export of grain, iron ore, steel, and other Ukrainian products, along with their import through alternative transport routes, namely the use of inland waterways, rail, as well as roadways. Solidarity lanes encompass all forms of trade and represent a novel collaboration between the government and business sectors within EU Member States, Ukraine, and the Republic of Moldova. In the European context, potential solutions could be derived from the coordinated interaction of border regions of neighboring countries, as outlined in the European Parliament's Resolution of September 15, 2022, on EU border regions: living laboratories of European integration [6]. This document calls on EU member and candidate

countries to increase the digitization of public services and reinforce interoperability policies. It emphasizes the necessity of supporting digital innovation in cross-border public services and business, welcoming the European Digital Innovation Centers (EDIC) in this regard.

Moldova's electronic communications sector plays a crucial role in today's economy, alongside the information technology sector, ensuring its digital transformation. Policies aimed at sustainable growth of the electronic and postal communications sector, considered as one of the sectors that promote and stimulate economic growth, transform and modernize governance, the social environment and the business environment. It is also worth mentioning Moldova's good position in international rankings:

- ICT Development Index – 86th place out of 169 [7];
- Network Readiness Index – 67th place out of 130 [8].

The volume of investments made in electronic communications amounts to 942 million lei (about 47 million euro) [9]. The largest investments have been made in the mobile telephony sector, intensifying the investment process in 3G/4G networks and fixed line networks. As far as the electronic communications infrastructure is concerned, all localities in the country are provided with fixed telephony, mobile telephony and internet access.

The Moldavian's 4G signal coverage is 97% of the territory and 99% of the population, respectively, ensuring a level above the European average in terms of access to the latest generation mobile networks. As for the 3G networks, they cover 99.7% of the country's territory and population with a signal. In recent years, all necessary national procedures for signing 2 regional agreements with Eastern Partnership countries have been carried out and completed, namely:

- The Regional Agreement on the Regulation of International Roaming Services in the Public Mobile Network in the Eastern Partnership Countries;
- Regional Agreement on harmonised technical conditions for Eastern Partnership countries for terrestrial mobile radio communications in the 694-790 MHz and 3400-3800 MHz bands. The agreement will facilitate the implementation of 5th generation (5G) mobile networks, ensuring that Ukrainian networks do not fail.

An assessment of the extent to which e-trade, e-logistics and Digital Transport Corridors (DTC) [10] are used in the Regional Policy environment, at all stages of the supply chain by the involved EU members and the new candidate countries Ukraine and Moldova, part of the Pan-European Transport Corridor System [11], shows that the effective functioning of the e-government concept can be achieved on the basis of the results of the INSPIRE Directive [12]. The Three Seas Initiative brings together the Baltic, Adriatic and Black Sea transport corridors [13]. This continental European "E-Government" model [14], within the framework of the "Interoperable Europe" program [15], will be characterised by:

- The existence of supranational institutions whose recommendations will have to be implemented by all EU countries;
- A high degree of integration which is reflected in the common currency, the common information space, preparation of a new common Constitution, etc.;

- Legislation regulating information relations in the European information space;
- The application of technology [16] in this model is primarily oriented towards the needs of citizen, business-users.

The possibility of connecting to digital transport corridors between the Adriatic Sea, the Black Sea and the Baltic Sea, with the possibility of extending this practice to other countries, first of all for the Eastern Partnership, is a great interest to the EU candidate countries. In order to structure and support the completion of the trans-European transport network, nine main network corridors and two horizontal priorities have been created, crossing Europe from East to West and from North to South along important transport routes [17]. The TEN-T network [18] aims to create a single European transport area that is complete, integrated and multimodal, including land, sea and air transport, covering and connecting all EU Member States in an intermodal and interoperable way. The European policy for Trans-European Transport Networks (TEN-T) and Energy (TEN-E) Networks [19] was established in 1993 through Articles 170-172 of Title XVI of the Treaty on the Functioning of the European Union [20].

The Republic of Moldova, as a candidate for EU membership, signed an agreement with the European Commission "On Accession to the Connecting Europe Facility (CEF)" [21], aimed at supporting regional and local administrations and target groups in the implementation of infrastructure projects in the transport, energy and digital sectors, in order to improve connectivity with EU neighbouring countries. The program will support the integration of the Republic of Moldova into the EU Single Market, contributing to economic growth, job creation and competitiveness. In the area of transport, the local public administrations and companies will be eligible for support under tenders in the current program period (2021-2027). The priorities of the program are the digitalisation of customs logistics administrative processes, cross-border trade and the strengthening of interregional innovation cooperation. The I3 Innovation Tool provides an opportunity for cooperation with key strategic partners such as the US, Canada and Norway, while facilitating interaction and dialogue with regional partners and enlargement countries such as Ukraine, Moldova and the Western Balkans [22].

2. Implementation "smart specialisation" to jointly promote innovative territorial transformation

The "Rail-Road-Air Mobility" strategy for the Danube Region [23] aims to increase the mobility and multimodality of rail, road and air transport and to develop a climate-resilient, intelligent safety and intermodal TEN-T network. The objectives coordinated by Serbia and Slovenia in priority area 1b Rail-Road-Air Mobility of the Danube Strategy are formulated as:

- Supporting fully functional multimodal corridors of the TEN-T core network by 2030;
- Support for improved regional air connectivity and implementation of the Single European Sky [24];
- Promoting better second and third class roads in the Danube region;
- Supporting safe and sustainable transport and mobility in the Danube Region.

With the implementation of national and sectoral regional development plans [25] in the context of Moldova's EU integration, public administrations have a need for an evidence-based advisory service that they can directly access and which is based on their needs. Intelligent business models need smart processes, which in turn are based on technology and media used in a purposeful way.

The Innovation Incubator IT4BA at the Academy of Economic Studies of Moldova [26], in collaboration with the residents, can play the role of an interdisciplinary competence centre for digital transformation in the public sector, which will conduct capacity building activities in public administration under digital change in the development regions of Moldova.

The modernisation of education and research programs should be aligned with sectoral regional plans developed by regional development agencies. In the context of the implementation of national strategies and in particular the Smart Specialisation Strategy 2030 [27]**,** one of the main objectives of innovative public-private partnerships is the creation of spin-off organisations within universities [28]. Such organisations tend to be one of the main forms of commercialisation of research and development (R&D) in the EU. In order to open up new opportunities for smart specialisation, regions and countries should analyse their position in European and global value chains. In this context, and in accordance with national legislation [29], the Regional Councils are required to review the studies, analyses and recommendations for implementation of the Regional Development Strategy [30]**,** regional development issues, need for intervention and other documents developed by the Agencies.

According to the Code on Science and Innovation Republic of Moldova [31], local public authorities participate in the formation and implementation of state policy in the field of science and innovation at the regional level, as well as finance regional programs and projects in the field of science and innovation from the budgets of administrative-territorial units. Experts in public bodies have pointed out that the most important problem in the above context is the training of innovation management staff in public bodies responsible for innovation planning at the decision-making levels.

The "Agreement with the EU regarding the participation of the Republic of Moldova in Horizon Europe, the Union's Framework Program for Research and Innovation" [32] states the following objectives of the "Joint EU-Republic of Moldova Research and Innovation Committee":

- To ensure the level of (mutual) openness necessary for legal entities established in each Party to be able to participate in programs and projects of the other Party;
- Exploring ways to improve and develop cooperation; jointly discussing future policy directions and priorities related to research and innovation, and planning research of common interest;
- Exchange of information, in particular on new legislation, decisions or national research and innovation programs relevant for the implementation of this Agreement, etc.

The European Union's Interregional Innovation Investment Instrument I3 work program aims to promote innovation through "smart specialisation" and interregional cooperation. Integration into the I3 program, will allow administrations of development regions and ATUs of the Republic of Moldova to support closer inter-regional investment cooperation and establish sustainable linkages, bringing together regional ecosystems into common smart specialisation areas, vital to accelerate market uptake of research results and foster innovation**.**

3. Data importance for the smart human settlements economy and interregional cooperation

The European data space [33] provides businesses in the EU with the opportunity to expand their operations within the European single market. Common European rules and effective enforcement mechanisms should ensure that [34]:

- Data can circulate within the EU and across sectors;
- European rules and values, in particular personal data protection, consumer protection legislation and competition law, are fully respected;
- The rules on access to and use of data are fair, practical and clear, and clear and robust data management mechanisms are in place; here is an open but determined approach to international data flows based on European values.

This planning of activities in EU candidate countries, under the theme "Deploying Data Spaces for Smart Communities", involves piloting data and applying the principles of a cross-border data space for smart communities. This should be defined in national and regional plans, on a large scale and with good geographical coverage to build the capacity of EU regions and candidate countries in connecting data from all relevant domains, according to their specific legislation.

This data should facilitate fine-tuning and improvement of plans, through continuous feedback to European and national projects. This data space should be controlled by public data holders using tools based on open standards and supported by a common middleware platform. This should also create synergies between funds and projects.

A digital transport corridor includes data-related services across physical transport corridors for end-to-end information exchange at all stages of transport - by air, road, rail and sea. The concept of digital transport corridors has been adopted by the European Commission and a related pilot project has been included in the EU's "20 Deliverables for 2020" working paper for the Eastern Partners Program 2018-2020 under point 7 "Harmonisation of Digital Markets" (HDM) [35]. In addition, the development of DTC in the Eastern Partnership, contribute to the post-2020 political objective of the Eastern Partnership "Partnership that builds" through increased trade and further regional and bilateral integration of economies.

EU4Digital [36] experts have identified preparatory actions for a Digital Transport Corridor between the Baltic Sea and the Black Sea, which can be fundamental for the creation of Digital twins [37] digital transport corridors. The best practices of the Ionian and Adriatic Sea transnational program [38] can be translated into the regions of the EU

candidate countries of the Black Sea and Danube Strategy basins, integrating stakeholder initiatives into the Three Seas initiative. The levels of information exchange from the local level to the transboundary DTC level are presented in the Figure 2 below:

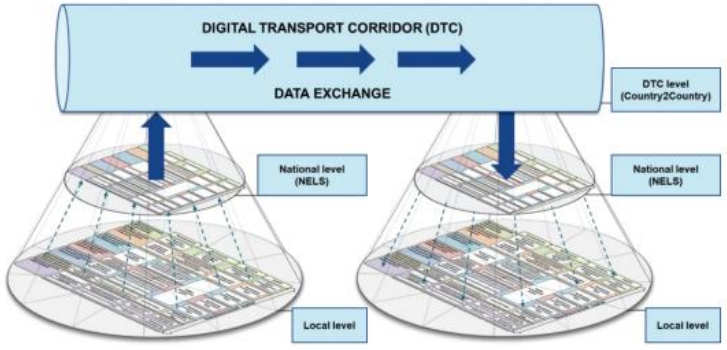

Fig. 2. Digital Transport Corridor data exchange [3]

The results of the European best practices, allow the expansion the range of the innovative services being developed and the effective management of modern innovation infrastructure in the regions. This will facilitate the implementation of hybrid mobility, creating the necessary for adequate management of data sets.

The EU-Ukraine "Solidarity Lanes" initiative is a collaborative effort among several entities, including the European Commission, relevant authorities, and the transport community. Its primary objective is to address bottlenecks that impede the efficiency and capacity of the Solidarity lanes, with the goal of facilitating Ukrainian exports and imports across all sectors. This entails implementing measures to enhance transportation management and streamline border procedures and inspections. Additionally, the initiative involves investments in infrastructure and logistics equipment. Furthermore, the implementation of Solidarity lanes will lay the foundation for long-term links between Ukraine and the EU, and will play an essential role in the recovery and integration of Ukraine and the Republic of Moldova into the European Union single market.

One example of a best practice that can be taken as a basis for the development of indicators and data in the regions of the Republic of Moldova, at European level, is the objective of priority 1b "Potential accessibility by air" [39]. Accessibility potential describes how easy it is for residents of one region to reach residents of other European regions, in this case by air. It is calculated based on two elements: the population in the NUTS 3 regions [40] and the effort (time, distance) it takes to reach them. The accessibility model used by ESPON [41] measures the minimum travel time by air between all NUTS 3 regions. In principle, for each NUTS 3 region, potential accessibility is calculated by summing the population in all other European regions weighted by travel time. The methodology for this indicator was developed within the ESPON Tracc project [42]. The political dimension of this priority is to improve accessibility, which is an overarching objective at all levels of the political system and is key to economic success. At the macro-regional level, Priority Area 1B aims to support the improvement of regional air connectivity and the implementation of the

Single European Sky initiative (SES) [43]. The provision of infrastructure, and in particular the provision and management of airports, is left to national discretion, so cooperation in the Danube Region has focused on other modes of transport.

The EU supports digitalisation, including at regional airports [44], through several initiatives. Established as the technological backbone of the SES initiative, SESAR (Single European Sky ATM Research) [45] aims to improve the efficiency of European aviation by providing and deploying technological and operational solutions that meet the objectives of the digital era. Since 2008, SESAR has researched, tested and delivered many solutions tailored to the operational and business needs of airports. For example, they help to integrate the use of drones at airports to a greater extent, help pilots to navigate at the airport, and maintain accessibility at secondary airports.

For mobility and transport companies, especially smaller ones, successful digital transformation as part of DTC projects can be a real challenge. The European Digital Innovation Centres (EDIH) [46], supported under DIGITAL, should function as one-stop shops, supporting companies in their digitalisation. They should provide access to technical expertise and experiments, the opportunity to 'test before investing' and innovative services such as financial advice, training and skills development. They should also address environmental challenges, such as energy consumption and carbon reduction.

Based on an analysis of best practices and specialised projects in the EU and EaP countries, the following Digital Transport Corridor technical vision (Figure 3) has been developed.

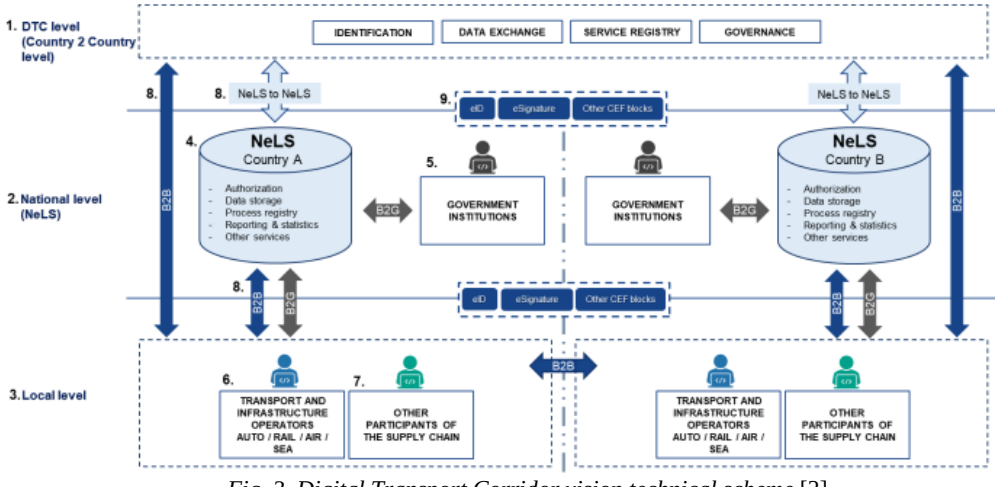

Fig. 3. Digital Transport Corridor vision technical scheme [3]

The technical vision of the DTC encompasses the following processes:

- The DTC level (country to country) is cross-border exchange of information in real time for more efficient interaction of participants in the supply chain of goods and flow of passengers. This is a system-to-system interaction between federated systems (platforms) from one specific participant in one country to a specific participant in another country.

- The national level is a trade facilitation area including National e-Logistics System (NeLS) [47] and governmental institutions. At this level, the primary set of transport and logistics services is concentrated, and regulatory compliance is performed.
- Local level – business-to-business and business-to-government operations, processes for exchanging information that results in logistics actions, documents, allowances/prohibitions to proceed. The set of services will be developed in stages, beginning with the basic components for specified sets of logistics data exchange. It is possible that the services will be expanded to include such features as a digital marketplace, insurance, and more.
- Government institutions: These are the country authorities that perform regulatory functions or require logistics information to be submitted via NeLS. Other participants and intermediaries of the supply chain, such as other participants or platforms that support similar features and could be integrated to exchange data, are also included.
- The following information flows are also included: B2B; B2G; NeLS 2 NeLS.

4. Proposal for the Republic of Moldova to implement the European Interoperability Framework for Smart Cities and Communities (EIF4SCC)

The European Commission actively supports local administrations and other actors that face challenges related to interoperability of services for citizens and businesses. The aim of EIF4SCC [48] is to provide EU local government leaders with definitions, principles, guidelines, practical examples of use drawn from cities and communities across Europe and beyond, and a common model for facilitating service provision to citizens across different areas, cities, regions and borders. In this context, priority 1b "Mobility of rail, road and air transport" can be linked to the European Commission supported Urban-Air-Mobility Initiative Cities Community (UIC2) [49], part of the EU Smart Cities Market Program [50], created in October 2017. UIC2 expresses the views of the population of European cities and regions in the evolving urban air mobility sector. The initiative develops its work and positions based on the recognition that cities and regions [51] are best placed to define the fundamental characteristics ecosystem of Urban Air Mobility (UAM) services [52] in order to meet the needs of their citizens. Local authorities can not only play an influential or even decisive role in the development of infrastructure, physical and digital assets for UAM, but also in co-shaping policy, regulatory and legislative issues [53], both at national and European levels. Ongoing work led by the European Commission links the EU Intelligent Mobility Strategy to the recently announced Urban Mobility Framework (UMF) [54] as well as to Strategy 2.0 on drones [55]. In December 2021 UIC2 finalised the first briefing for practitioners on Urban Air Mobility and Sustainable Urban Mobility Planning (SUMP-UAM), published by Eltis [56], the EU Mobility Observatory.

Recognising the importance of interoperability and the particular challenges it presents in the urban context, the Commission (DG DIGIT [57] and DG CONNECT [58]) published a Proposal for a European Interoperability Framework for Smart Cities and Communities, covering the areas shown in Figure 4.

Fig. 4. EIF4SCC concept [48]

The proposal for EIF4SCC identified six aspects of interoperability that are important in a city and community context, similar to the 2017 European Interoperability Framework [59] levels with the addition of cultural interoperability:

- Technical Interoperability - covers the applications and infrastructures linking systems and services;
- Semantic interoperability - the semantic aspect refers to the meaning of data elements and the relationship between them;
- Organisational interoperability - refers to the way in which public administrations align their business processes, responsibilities and expectations;
- Legal interoperability - is about ensuring that organisations operating under different legal frameworks, policies and strategies are able to work together;
- Cultural Interoperability - refers to steps taken by individuals and organisations to take into consideration their social and cultural differences and, if applicable, organisational cultural differences;
- Interoperability governance - refers to decisions on interoperability frameworks, institutional arrangements, organisational structures, roles and responsibilities, policies, agreements and other aspects of ensuring and monitoring interoperability at local, national and EU levels.

A conceptual model for integrated service management in a smart city or community comprises six main elements:

- Service users, including inhabitants, visitors, businesses, organizations, and administrators, should play an active role in the co-creation of smart city and community services.
- Integrated services of smart cities and communities (SCC) may be offered by the public sector or through collaboration between the public and non-public sector.
- Service providers, both public and private, offer a diverse array of services to service users within a city or community.
- Data sources and services: A multitude of data sources exist within a city, including administrative data, scientific data, crowd-sourced and statistical data, data collected via

the Internet of Things, data collected via environmental and urban sensors, and data generated by people in the city.

- The advent of technology facilitate the collection, storage, sharing, updating, and preservation of data, thereby paving the way for the development of reusable services.
- Security and privacy are paramount considerations in the delivery of services. Both public and non-public actors must adhere to a privacy-by-design and security-by-design approach to ensure the protection of sensitive data.

The main challenge in harmonizing transport e-logistics and European data governance between the regions of EU states and candidate countries is to provide accurate information about transported goods at any point in time, from origin to destination via the transit regions of the countries making up the transport corridors. In the INSPIRE Directive [60], in the list of basic topics of Annex № 1, there is an item "Transport network. Road, rail, air and water transport networks as well as their infrastructures and links to the various transport networks". This includes the pan-European transport network as defined in Council Decision No 1692/96/EC and subsequent revisions. The list of transport network objects and their attributes is specified in Section 5.7 Transport networks of INSPIRE with an extended interpretation of the content of each of the 34 basic themes of the directive. The transport network dataset should contain information on the topographic objects forming the integral transport network layer and their attributes, representing a seamless set both within the national border of an EU Member State and the community as a whole, taking into account cross-border links of national networks. It includes road and rail networks, maritime and inland waterway networks, and airlines. The dataset must meet the requirements for navigation systems, the design of intelligent transport systems based on LBS services [61] and telematics.

5. Planning the technology landscape of digital transport corridors

One of Global Gateway's priorities [62] is to invest in clean transport corridors. The opportunities offered by emerging transport corridors for sustainable, efficient, smart, equitable, accessible, safe mobility and trade in the Western Balkans, the Eastern Neighbourhood and Africa, as well as between Europe and these partner regions should support territorial organisation (rural and urban). This is achieved through robust networks and services that create jobs and support value chains and can benefit sectors both in Europe and in partner countries.

The solution of the problems of the agri-food market (farmers) in the border areas of the EU countries and candidate countries in connection with exports from Ukraine is a high priority of the "EU-Ukraine Solidarity lanes". At the moment there are many large investments being made to improve logistics, including the improvement of road, rail and barge connections to facilitate the further transportation of grain, as well as the improvement of storage conditions in the countries in question. The need for better logistics will ultimately be to the benefit of these neighboring countries through the integration of the regions of the candidate countries into the "new markets" that will be available to them after the further integration of Ukraine and Moldova into the EU. In view of the logistical difficulties for countries such as Poland and Romania, [63] in the course of the research identified a number of examples of best practices of logistics centers based on smart digital

solutions that contribute to more efficient coordination of cargo flows. They are changing the technological landscape of the settlements along the corridors connected to the TEN-T, which is forcing the local public administrations to take measures in support of innovation. Through Smart and Sustainable Corridor Plans [64], urban and rural public administrations, can channel future economic growth and employment into commercial corridors running through Moldova, while maintaining the integrity of natural and environmental assets, with adjacent technological landscapes and residential areas. Greater density of people and jobs along the emerging digital transport corridors can encourage more frequent and reliable transit, increased smart mobility in rural areas, and the creation of walking, cycling and commuting communities in small towns and local initiative groups. Plans could focus on:

- Planning infrastructure convenient to transit freight, international tourist routes, cyclists, pedestrians and public transport;
- Increasing multifunctional development of settlements and land;
- Reducing greenhouse gas emissions through greater use of public and private electric transport, walking and cycling;
- Attracting more commercial and industrial businesses and jobs to local cluster initiatives and industrial parks;
- Preserving open space in cities and villages while reducing urban sprawl; and supporting the rest of the work to update spatial development plans.

All these activities will require structuring the available information and creating the necessary data for adequate decision-making, especially in projects with European funding.

Data exchange within Digital Multi - modal Transport Corridors [65] is based on the provisions of the European Federated Network of Information eXchange in LogistiX [66] in close connection with physical transport corridors. It is built according to existing EU requirements (DTLF, eFTI) and is continuously adapted on the basis of new specifications and provides different types of services [67]:

- Visual-administrative - it includes establishment of NeLS and Living Labs facilitating exchange of different sets of data for different modes, including eCMR, eSMGS/CIM, eCertificate of Origin and eTIR;
- Visual-physical - it includes usage of tracking information for faster border crossing;
- Information - services for corridor information systems defined by DTLF;
- Quotation - services for corridor information systems defined by DTLF;
- Marketplace - services for corridor information systems defined by DTLF;
- Booking and ordering services - services for corridor information systems defined by DTLF.

The DTC in the EaP countries is seen as a network of centralised national solutions representing national e-logistics systems. DTC should become a new building block of digital infrastructure capable of supporting and ensuring efficient transport of goods in the EaP countries along the European TEN-T transport corridors. The concept developed for the Baltic Sea-Black Sea corridor complements the extension of the TEN-T corridor North Sea-Baltic Sea. The concept can be adapted and implemented to complement the extension

of other TEN-T corridors in a complementary Black Sea - Caspian Sea corridor including Armenia, Azerbaijan, Georgia and the Republic of Moldova [68].

National sections of the regions comprising the physical pan-European transport corridor can be developed as part of a network of established Living Labs on one of the transport modes between several countries and then extended to additional transport modes. The development of a new "Smart Mobility" program from the Black Sea to the Adriatic Sea, could be useful in the integration of the candidate countries Ukraine and the Republic of Moldova into the "Three Seas" initiative [69]. The Living Lab Trieste (Figure 5), Friuli-Venezia Giulia region in Italy [70] can serve as a model for a national, regional laboratory logistics system.

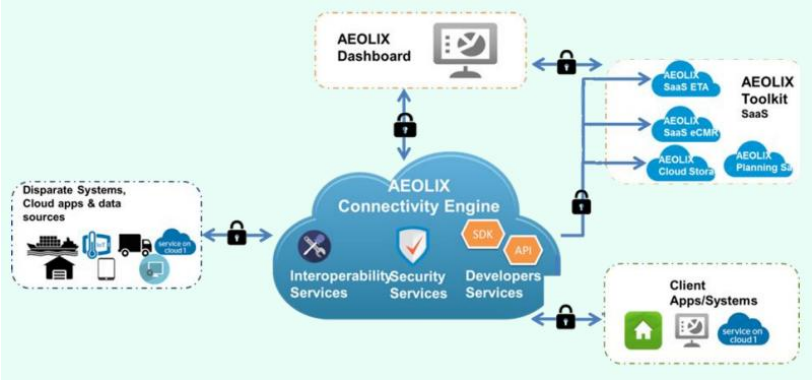

Fig. 5. Living Lab architecture [70]

The objectives of Living Lab are:

- To provide technological solutions to enhance and simplify cooperation between supply chain actors;
- Introducing basic functions to improve, optimise and automate transport and logistics operations in supply chain cooperation;
- Facilitating information exchange in an integrated security framework;

The objectives of the software infrastructure:

- Streamlining of customs procedures;
- Improve the efficiency and quality of intermodal transport in Trieste, by implementing the Living Lab software application infrastructure (Figure 6), providing the Port and Interporto di Trieste with future growth management and rail transport incentives.

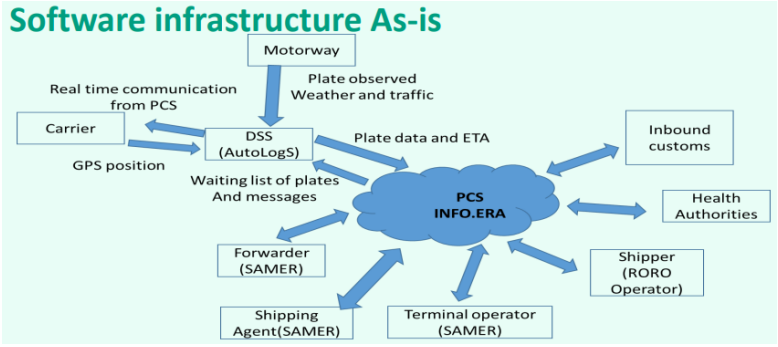

Fig. 6. Trieste Living Lab app [70]

Benefits of implementing the Living Lab approach:

- Logistics information exchange harmonised with EU - simpler, faster and more reliable;
- Increased digital maturity of different modes of transport within the Eastern Partner countries and abroad;
- Living Labs will create a consolidated solution - NeLS (avoidance of fragmentation);
- Tested (pilot) and later - operational DTC solutions;
- Gradually created data pipeline;
- Closer cooperation and interaction between different logistic actors in the EaP (getting organized).

Uninterrupted cross-border geospatial information made available through the European Positioning System helps increase the exchange of security related road data. It can also help accelerate customs data exchange within the European Customs Model Trans-European Customs Systems (EUCDM) [71] (Figure 7).

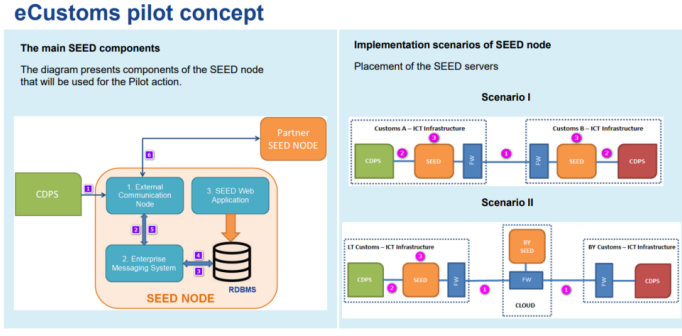

Fig. 7. e-Customs concept [71]

Preparatory steps for the implementation of the e-Customs concept are:

- Formal appointment of experts for the pilot project;
- Determination of the scope of data to be piloted;
- Capability to extract data at national level;
- Establishment of triggers for information exchange;

- Signing of a Memorandum of Understanding to participate in the pilot project.

In accordance with the recommendations of the project "Analysis and Selection of Eastern Partner Countries for Pilot Information Exchange Mechanisms," the eCustoms concept may be utilized as a foundation for the implementation of cross-border activities under Scenario 1 at the Moldova-Ukraine border. The EU Open Data Directive 2019/1024 [72] is designed to facilitate the cross-border multiple use of data in Europe.

The advent of open data has enabled EU members to utilize web-based application programming interface (API) services for access. In light of the unprecedented rate of data growth, the new model has created a single European open data market, from which all members will benefit.

As EU members complete the implementation of the Open Data Directive, geospatial tools must support the interoperability requirements of data catalogues for open data portals across Europe. To extend support for the directive, Esri, the global leader in GIS [73], is extending the interoperability capabilities of the ArcGIS Hub web services, metadata, and catalogues APIs. The use of international open standards, such as the Data Catalog Vocabulary Application Profile (DCAT-AP 2.0.1) [74], enables European customers to share data that is compliant with the new open data directive and facilitates the reuse of their open data catalogues and web services.

The integration of the Data Catalog Dictionary Application Profile (DCAT-AP 2.0.1) with the extensible ArcGIS Hub architecture provides guidance for geospatial technology users in their adoption of the legal requirements of the Open Data Directive, thereby paving the way for greater accessibility and transparency. These changes will open avenues for enhanced collaborations and innovations across EU Member States in Europe.

6. Conclusions

In order to establish and support digital TEN-T transport corridors in the Republic of Moldova as well as to develop deeper cooperation on cross-border exchange of customs data with the regions of neighbouring and third countries, the competent national and regional organisations should consider the possible benefits of further automation of data collection processes and cybersecurity measures. Integration of development regions into the Instrument for Interregional Innovation Investments (i3), provides open access to the best practices mentioned above, which significantly improve the quality and confidence of investors in joint projects within the framework of European standards and norms. According to [69], we identify the following benefits that the new Interregional Innovation Investment (i3) approach implies for the Republic of Moldova:

Government agencies, public administrations and businesses are able to increase transparency throughout the supply chain from the point of export to the point of entry for the same type of goods. Processing the movement of goods is accelerated and resource planning capabilities are improved through access to pre-arrival information. Authorities' ability to systematically identify and manage risks is enhanced through the development of secure electronic tools for the systematic exchange of reliable information. Border

management costs are reduced and revenue collection is increased by reducing the number of physical inspections and improving risk management in targeted customs controls. These activities will help harmonize standards and data models, and streamline processes.

In the context of integrated border management priorities, stakeholders will receive expedited customs procedures for border crossing and facilitation of legitimate trade, enhancing their competitiveness. Data harmonisation will ensure transparent and predictable processes for all partner countries, reducing the cost of intraregional and cross-border trade by facilitating the flow of goods across borders for compliant traders. Productivity with fewer resources, efficient use of human resources will promote the concept of a single window for coordinated border management, encouraging government agencies to work together, reducing security risks in the region. Establishment of Living Lab NeLS, will enable and facilitate the digitalisation of cross-border exchange and management of logistics information, reducing the administrative burden, in particular: reducing the cost of printing, archiving, checking and processing paper documents, in order to improve data security and quality, easier access and environmental friendliness.

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Trafficking in human beings in the digital age – barrier to dignity, freedom and justice

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Abstract

This paper aims to explore the evolving dynamics of human trafficking, particularly focusing on how technology and the online environment have facilitated the expansion of this global crime. The objective is to analyse the role of digital platforms in transforming traffickers' operations and recruitment strategies, with an emphasis on emerging trends and technological solutions for prevention. Existing research has extensively examined human trafficking's exploitation for sexual and forced labour purposes, highlighting the growing involvement of women, girls, and men as victims. Additionally, international human rights law has long recognized human trafficking as a severe violation of fundamental rights. Previous studies have emphasized the significant economic gains traffickers accumulate, with annual profits estimated at $150 billion. The paper reviews current statistics and case studies to illustrate how traffickers have adapted to technological advancements, particularly in the wake of the COVID-19 pandemic. It discusses the increasing abuse of online platforms and digital tools for recruitment, exploitation, and operational efficiency in human trafficking networks. Furthermore, the paper explores how technological advancements can be leveraged to strengthen legal frameworks and enhance prevention measures. Human trafficking remains pervasive, with 50% of victims exploited for sexual purposes and 38% for forced labour. A notable trend is the digital transformation of trafficking practices, spurred by the pandemic, which has increased traffickers' reach and sophistication. However, this trend also presents opportunities to deploy technology for countering trafficking. The findings underscore the urgent need for legal systems to adapt to the technological landscape. Policymakers and stakeholders must prioritize technology-driven prevention and detection mechanisms to address human trafficking effectively. This paper provides valuable insights into the intersection of technology and human trafficking, highlighting both the challenges and potential of digital tools in combating one of the world's most pressing human rights violations.

Keywords: technology-driven, digital safety, prevention through technology, technology’s dual role, exploitation vs. prevention.

1. Introduction

Human trafficking remains one of the world’s fastest-growing criminal industry, while also being one of the world’s most serious human rights violations, a real global challenge. The phenomenon manifests in different forms and its victims come from any region or country and from all age groups. The image of trafficking in human beings, which usually includes children and women, is not pleasant, but the reality of its presence in the world around us must be made aware, especially in the light of recent developments, which substantially alter the cycle of human trafficking. More recently, trafficking has become deeply entwined with the digital landscape, as traffickers seem to be relying more and more on digital platforms and online networks in all stages – recruitment, exploitation and control of the victims. In the context of smart cities and the rapid expansion of connected technologies, the online environment is used as means of creating new challenges. Social media, advertisements, sites/applications (the so-called “apps”) for job search, encrypted communication channels, online marketplaces and even digital financial systems have enabled traffickers to refine their operations, while extending their reach and efficiency.

Fig 1. Forms of exploitation for registered victims of THB (trafficking in human beings) between 2008-2022
Source: Eurostat, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Trafficking_in_human_beings_statistics_Highlight_24-01-2024.png

It is estimated that between 20,000 and 50,000 people are trafficked globally each year. The UNODC Global Report (2020) reveals the cruel truth about the current situation and the evolution of the phenomenon. Currently, 1/3 of the victims of human trafficking are women and girls, while 20% of the victims are adult men. Of the different types of exploitation, 50% of victims are trafficked for sexual exploitation and 38% for forced labour exploitation [1]. According to the OSCE [2], trafficking in human beings generates an estimated annual profit of 150 billion for traffickers, of which about 95% is related to trafficking for the purposes of the above practices, which are among the top of those used by traffickers.

The COVID-19 pandemic has further accelerated this shift to online trafficking methods, as traffickers adapted the new conditions, such as increased digital engagement, which was supported by the lockdown measures and economic strain. While a new subcategory of vulnerable individuals was evolving, the need for new, tech-driven solutions to counter the severe phenomenon, was also intensified. Within smart cities, there are powerful tools and means to monitor suspicious activities, identify victims and collect relevant data. Therefore, the opportunities to leverage technology to prevent THB are considerable, taking into account the on-going advances in artificial intelligence, real-time data collection, digital surveillance, which are able to support the enhancement of legal frameworks for prevention and enforcement.

Digital platforms play a significant role in the expansion of trafficking operations, but still, they can be viewed as unique opportunities to prevent and combat this phenomenon. By shifting the focus into developing effective, technology-driven mechanisms and tools to detect and deter trafficking, we can ensure changing the mindset from vulnerability to power. Smart cities are crucial in the framework of transformative effects of digital technologies on human trafficking. Urban environments are expected to strengthen their digital security measures and integrate anti-trafficking protocols within the evolving

landscapes of smart cities. The current momentum highlights the urgent need for various actors in the field of policymaking, tech innovators, urban planners and public authorities at all levels, to prioritize digital safety and human rights for citizens.

2. The evolution of human trafficking: from historical slavery to modern exploitation

The origins of human trafficking are deeply intertwined with the history of slavery, one of the oldest forms of exploitation. Slavery was widespread and legally sanctioned in many societies until the 19th century. It was only in 1807 that Britain introduced the first formal anti-slavery law, the Slave Trade Act, marking a pivotal moment in the fight against this form of exploitation. In 1833, the Slavery Abolition Act extended this by fully outlawing slavery in the British Empire [3]. However, despite these early legislative changes, the practices associated with human exploitation persisted globally. In addition to black slavery, "white slavery" emerged as a term in the 19th and early 20th centuries, referring to the forced recruitment of women and girls into prostitution through coercion, deceit, or drugs [4].

Efforts to combat this exploitation resulted in the International Agreement for the Suppression of the White Slave Trade [5] in 1904, later reinforced by the 1910 International Convention for the Suppression of the Trafficking of White Slaves [6]. Although these agreements signified international recognition of the problem, effective action was limited due to global conflicts such as World War I, which disrupted international cooperation.
The establishment of the League of Nations in 1921 facilitated a shift in terminology and approach, reflecting a broader understanding of trafficking as an issue affecting both sexes and all age groups. This led to the 1921 International Convention for the Suppression of Trafficking in Women and Children (Geneva), expanding protections against sexual exploitation [7]. Subsequent efforts, including the 1933 Convention for the Suppression of Trafficking in Women of Legal Age, reinforced these protections.

Following World War II, the United Nations was established in 1945, embodying an international commitment to human rights and freedoms. This focus continued with the 1949 United Nations Convention for the Suppression of Trafficking in Persons and the Exploitation of Prostitution, the first legally binding document addressing human trafficking as incompatible with human dignity. According to the preamble to the Convention, "prostitution and the evil that accompanies trafficking in human beings for the purpose of prostitution are incompatible with the dignity and value of the human person and endanger the welfare of the individual, the family and the community" [8].This convention framed trafficking as a direct affront to the rights and welfare of individuals, families, and communities.

2.1. The 21st century shift: defining and combating modern trafficking

In 2000, the UN introduced the Convention against Transnational Organized Crime, which included a critical advancement: the Protocol for the Prevention, Suppression and Punishment of Trafficking in Persons, in particular Women and Children. It entered into force at the end of 2003 and contained a particularly important feature for the regulated field, namely the first definition of trafficking in human beings. According to Article 3, "the term trafficking in human beings means the recruitment, transport, transfer, housing

or reception of persons, by threat of recourse or by the use of force or other forms of coercion, by kidnapping, fraud, deception, abuse of authority or vulnerability, or by offering or accepting payments or benefits to obtain the consent of one person having authority over another for exploitation purposes. The exploitation shall contain, at least, exploitation by prostitution of another person or other forms of sexual exploitation, forced labour or services, slavery or practices analogous to slavery, the use or removal of organs".

In the same article, the irrelevant consent of the victim is mentioned and the inclusion of children under 18 years of age in the category of victims of human trafficking, regardless of the means used for this purpose [9]. This protocol provided the first comprehensive international definition of human trafficking, encompassing the recruitment, transport, and exploitation of individuals through coercion, deception, or abuse of vulnerability. It clarified that victim consent is irrelevant in trafficking cases and recognized minors under 18 as trafficking victims irrespective of coercion.

This evolving international legal framework reflects a growing recognition of trafficking's complex dynamics, especially as technological advancements create new avenues for exploitation. The historical context underscores the need for continuous adaptation of legal definitions and policies to address the persistent and evolving nature of human trafficking.

Human trafficking is often seen as a modern form of slavery adapted to the 21st century, especially in the light of activities associated with the phenomenon, such as sexual exploitation of victims, forced labour, exploitation through indebtedness, slavery in its various forms, and also for the purpose of organ harvesting. According to the latest International Labour Organization report, since 2022, almost 50 million people today face the phenomenon of modern slavery, which means that, almost one in every 150 people in the world is in a situation of modern slavery or in a form associated with it, in any day [10].

Modern slavery, as in the case of human trafficking, poses a greater danger to vulnerable people, immigrant workers, who do not benefit from protection, people excluded from society, discriminated against or poor. Their vulnerability has increased even more in recent years amid the negative effects of the COVID-19 pandemic, which led to an increased risk of modern forms of slavery. Among the most common forms of modern slavery facing the world today, we encounter situations of forced labour and forced marriage. According to the same ILO 2022 report, forced labour has seen positive increases in recent years, with current estimates at around 27.6 million people in forced labour daily. In this paper, we refer to forced labour as "any work or service which is obtained from any person under threat of punishment and for which that person has not voluntarily offered himself" [11], revised definition, included in the Protocol adopted in 2014 by the governing body of the International Labour Office.

Trafficking in human beings does not automatically involve the movement/transport of the victim from one place to another or even outside the border, in order to exist. For this reason, modern slavery and human trafficking are, in practice, particularly similar. According to `Walk Free`, the international human rights group, "modern slavery refers to situations of exploitation in which a person cannot refuse or leave because of threats,

threats, and threats, violence, coercion, deception or abuse of power" [12]. In conclusion, we can affirm that the phenomenon of human trafficking is included in the modern slavery phenomenon, along with the practices of forced labour, forced marriage and sexual exploitation, as presented above.

According to data [13] provided by the US and Canadian governments and agencies specialized in human trafficking and related fields, for human traffickers we can distinguish between the following three categories:

- individual traffickers;
- traffickers who are members of small (decentralized) criminal groups, sometimes only participating in certain practices, such as the recruitment or transport of victims;
- traffickers involved in large criminal organizations (who use the profit generated by their operations and use it further to fund other such activities).

The data shows that human traffickers are often of the same nationality as their victims, allowing them, whether acting individually or as part of criminal organizations, to use the most appropriate methods of exploiting victims, managing to capture their vulnerabilities more easily, in the context in which they come from the same environment and having the same culture, language and history. With regard to transnational human trafficking networks, it is often the case that traffickers, while having a different nationality from their victims, build partnership relations with residents of the victim's country of origin, in order to facilitate recruitment and transport operations, as well as providing false travel documents for victims, where appropriate.

Human traffickers are often involved in other criminal activities, such as economic fraud, drug trafficking or similar, but there are situations when human trafficking activities are carried out under the umbrella of industries, real businesses, used to justify the profits generated by the exploitation of victims, as a result of human trafficking. Of course, apart from owning such a legitimate business, they themselves, human traffickers really need industries such as transport firms, hospitality industry, financial institutions, real estate agencies or advertising to function.

As far as victims of human trafficking are concerned, they come from any region of the world, include all age, race or gender categories, and are generally chosen and recruited based on the vulnerabilities identified by the aggressors. In particular, there is a tendency to trafficking women and children, considered among the most vulnerable categories. This category mainly becomes the category of victim's subject to sexual exploitation or forced marriage, while men are often victims of forced labour. The race, ethnicity, sex of the victims, the culture of which they belong, are not an eliminatory factor for traffickers. However, their vulnerability is a risk factor. This vulnerability can be individual or felt at the family level, but it can also arise strictly from existing social prejudices or other reasons independent of the victim.

2.2. New dimensions of trafficking

In the context of the expansion of online platforms and digitalization, with all the components involved, human trafficking has also evolved in terms of new tools and

platforms that are easy to use for recruitment, exploitation and control of the victims. As a direct impact, trafficking and exploitation of victims is present in the digital environment, online platforms – including both frequently used social media platforms (Facebook, Instagram, TikTok, WhatsApp, YouTube, Snapchat), as well as platforms promoting sexual content (Pornhub) or recently developed ones (OnlyFans) – which allow the sharing of images and video content, have become the main tools used by traffickers, both for the recruitment of victims, as well as to exploit them and obtain income from the sale of various advertisements or even services of a sexual nature. The online platforms have become commonly used and popular among traffickers, since they provide accessible channels for reaching potential victims across age groups and regions.

The international community is currently in a situation where the phenomenon of human trafficking and its associated activities, which originate in the early forms of slavery, are in a new era of development, almost at the same time as the latest technological developments. This shift to digital platforms significantly lowered the barriers for traffickers. Physical proximity being no longer essential, initiating contact, grooming and controlling of the victims is becoming easier to manage.

In essence, there is a wide array of tactics [14], which can be classified in three categories:

- *Recruitment using social media platforms*

Nowadays, the existence and continuous development of social media platforms has enabled traffickers with the possibility to operate under various identities while being present in the online environment. Through multiple profiles created, traffickers can identify, contact, groom and recruit vulnerable potential victims in the absence of any physical interaction and without raising any suspicions. There are several ways the traffickers can come into direct contact with vulnerable individuals. One of the most common ways is creating fake profiles and pseudonymous accounts in order to get closer to the victim and feature relatable content, considering the specific target demographics. Ads and posts can also be tailored to reach a specific audience, especially since traffickers focus on promoting high-paying job offers (also abroad), modelling jobs, that attract people who are struggling with financial stability or would like to create personal connections outside of their living country. Leveraging algorithms is also one mechanism that traffickers can leverage and reach vulnerable individuals by simply becoming more visible in the user's feed. Such algorithms are used by several well-known platforms, such as Facebook or TikTok to analyse the behaviour and preferences of users and recommending content, groups or posts to engage with. Once visible, they can make use of the vulnerabilities of the people they engage with and try to recruit them.

- *Content distribution and exploitation*

Today, there are numerous platforms and instruments which allow the elaboration and dissemination of explicit content for exploitation. These tools enable traffickers to generate substantial profits while remaining obscured from law enforcement. Often, the victims get trapped into a cycle of abuse, their attempts to seek help generating further threats against them. Victims can be convinced to produce and upload several categories of explicit content – whether photos, videos, even live-streamed content – by either being under a

personal threat or simply being manipulated. Therefore, in the first scenario, victims are threatened with exposure of personal information, blackmail, finances or physical harm, in order to make sure the traffickers get the explicit content they need and the victims always comply with their demands. In the second scenario, victims are convinced to willingly share explicit content in various forms, due to manipulation disguised into a romantic connection with the trafficker. A well-known tactic of such manipulation is known as *The Loverboy Method*. Social media platforms, adult content websites or emerging platforms (e.g. the recent OnlyFans) allow traffickers to upload, sell explicit content, via direct payments or monetizing views or subscriptions. OnlyFans platform allows victims to create a profile especially for subscribers who are able to pay a monthly fee in order to get access to exclusive content which is only available for them. Victims can also have discounts for subscriptions and display their links to these profiles on other social media platforms, inviting people to become subscribers. Live-streaming platforms are also being used to broadcast explicit content in real-time to those who are willing to pay. Explicit content can also be available for pay-per-view models or third-party websites and people (e.g. directly via Telegram, WhatsApp). The current concern is related to the fact that this tool provides the anonymity for viewers and also for private payment methods, allowing online paying systems such as cryptocurrencies to be used which makes tracking the money and people more challenging. Another challenge is also related to the difficulty of removing the explicit content once it has been distributed online (uploaded or sold). Many times, it is almost impossible to remove it entirely, since the content can be downloaded already, shared and even re-uploaded across many other platforms and websites.

- *Remote control and monitoring*

Compliance of victims is often ensured through various means of control and close monitor that enable the trafficker to maintain psychological dominance over their victims. Digital technology instruments allow this to happen even in the absence of physical proximity. There are features on daily used devices and social media platforms and apps that can be easily enabled by victims, willingly or being threatened. Smartphones are easy instruments which can be tracked via real-time location sharing. Having permanent information regarding location of the victim can also be obtained by location sharing features on social media platforms or messaging apps, as well as ride-sharing services. All GPS-enabled devices can be used to track someone's whereabouts and these devices enable traffickers to have access to them remotely, at all times, for surveillance. In some cases, traffickers convince the victims that permanently surveillance is needed for safety reasons. More advanced are spyware and monitoring apps which can be easily and secretly installed on victims' devices. These programs allow a close monitor by tracking the devices' calls, direct messages and online activity. Access to passwords and private conversations can be enabled also by keyloggers, which are designed to track the typing on a victim's device. More recently, evens apps such as mSpy or FlexiSpy, designed for parents and employers to use in order to track their children or work of the employees have been misused. Besides being able to keep a close eye on all activities, these apps allow for traffickers to get access including to the device's camera and microphone. The living environment can easily become the perfect target to tracking a victim's activity in the comfort of their own zone. The Internet of Things (IoT) devices from our homes, such as smart home systems, wearable fitness and health trackers are ways to ensure that a victim is being monitored

daily. Smart security cameras, as well as other home systems can be installed to ensure permanent watch on victims. Constant monitoring is sometimes well known for victims and can become an advantage for traffickers, discouraging victims to seek for help or escape from their homes. The COVID-19 pandemic accelerated the digital evolution of human trafficking. Amid lockdowns and heightened internet usage, traffickers expanded their online activities, focusing on individuals facing economic or emotional vulnerabilities. According to the Group of Experts on Action against Trafficking in Human Beings (GRETA), the covert nature of online trafficking significantly complicated efforts to identify and support victims.

Effectively responding to this digital shift demands collaboration among governments, technology companies, and law enforcement agencies to establish comprehensive monitoring and prevention systems. The advances in technology, including machine learning and artificial intelligence are tools which can be used for the benefit of authorities, law enforcement and ultimately, victims. Removing explicit content can be achieved more effectively through content recognition software, facial recognition technology and blockchain tracing and these instruments can even detect and trace back the origins of such uploaded materials. In this case, the need for collaboration between national governments, tech companies and NGOs is even more justified, since such measures require strict anti-exploitation policies and improvement in the monitoring mechanisms.

3. The digital transformation of trafficking operations

Every year, millions of people are trafficked in all regions of the world, and the ways of traffickers are now being transformed as a result of the integration of new internet technologies and the use of digital platforms. Thus, the recruitment and exploitation of victims takes on new dimensions, despite the existence of a comprehensive international legal framework for the protection of human rights and fundamental freedoms (e.g. The Palermo Protocol [9]). Moreover, the quantification of the phenomenon itself is extremely difficult, especially because of the clandestine nature of human trafficking. The COVID-19 pandemic, through the "new normality" created, helped to determine criminals to adapt their strategies for addressing and recruiting victims, in particular through the use and abuse of new communication technologies. In this respect, the General Report 2021 on the activities of GRETA [15] stresses that, among the effects of the COVID-19 pandemic, there is the high vulnerability of victims of trafficking in human beings and the difficulty of identifying and supporting them.

Today, the way in which technology is integrated into the strategies of human traffickers is even more varied, as they use the resources provided by the Internet for various purposes, such as recruiting victims (using social media channels, websites), promoting ads on the Internet (both for the provision of exploitation services and fake job offers to attract victims), by using technology to distribute images and videos illustrating services provided through victim exploitation, including live-stream, and for the promotion of ads related to the sale of organs and other services. The possibilities are, at this time, innumerable, given that the use of technology by traffickers today allows both direct contact with future victims, as well as new methods, such as creating false identities to get in touch with victims and other tools. Moreover, the distance between the aggressor and the victim is no longer

a problem, just as transporting the victim to a special place for exploitation is no longer the main form of human trafficking.

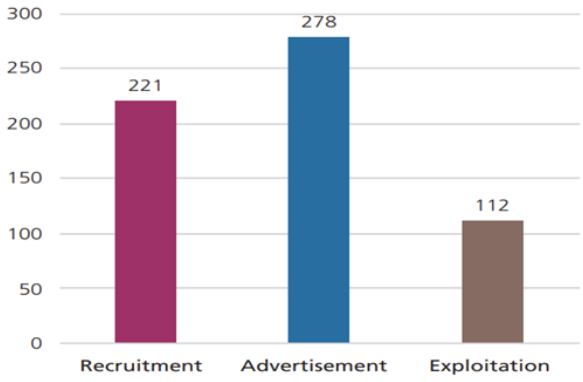

Fig. 2. Number of trafficking victims by types of activities carried out with the use of technology, as reported in the GLOTIP court cases, 2004-2018
Source: GLOTIP collection of court case summaries (supplemented with UNODC SHERLOC cases).

Information and communication technology and the emergence of the Internet have been a major influence in the conduct of social interactions and a vast range of actions that could be undertaken with much greater ease, thanks to the use of the latest technologies and resources available to people around the world. For this reason, all areas of life have benefited from the opportunities that the Internet and technologies offer, including, of course, the criminal sector, in which we include, in this case, human trafficking.

When it comes to criminal trafficking in human beings, the information and communication technology sector must be viewed from two perspectives: the use and abuse of technology. On the one hand, trafficking in human beings abuses discovered resources (the internet and the online environment) to recruit victims and take actions associated with trafficking in human beings. On the other hand, institutions, organizations and agencies around the world, which aim to prevent and combat the phenomenon, are currently trying to use the same resources to achieve their goals (identifying crimes and human traffickers, prosecuting and punishing them). As regards the use of technology to prevent and combat the phenomenon, there are currently limited databases/knowledge regarding technologically facilitated trafficking in persons and these are mainly based on reports from international organizations, to which information and data is added from NGOs or even police officers in a small number of states [16].

Digital technology has an increasing impact on the criminal trafficking industry around the world. Thus, it is noted that technology and the internet are integrated into the way human traffickers operate, at all stages of the phenomenon: recruitment, exploitation and monitoring, victim control, using the numerous resources at a click away, regardless of where both traffickers and potential victims are located or even victims of activities associated with human trafficking.

• *Victim recruitment phase* – allows traffickers to obtain data that can be used later: identification data of potential victims, their location and contact details. At this stage, digital platforms, social media platforms (e.g. Facebook, Instagram, Twitter, Snapchat, TikTok, WhatsApp), websites, dating apps or even online games (chat) are used for various purposes, such as: add sharing, job adds, interactions, social networking.

• *Victim exploitation phase* – occurs after the recruitment of victims by traffickers, through the methods presented in the recruitment phase and the online interaction with the victim. Thus, by using social/dating apps (e.g. recruitment by using the method called *Loverboy* [17]), victims are recruited by traffickers and can be exploited through the following tools: use of compromising photo/video material for online distribution and/or profit from selling them and/or sexual services provided by victims, blackmail victims for sexual activities/services, live streaming. Also, using online platforms to distribute fake ads or job applications, victims are recruited for forced labour or related activities. Payment for services resulting from the exploitation of victims can also be made through online payment means/instruments (internet banking, MoneyGram, cryptocurrencies). For example, by using cryptocurrencies, both the receipt of money and the handling and hiding of it is facilitated, so that it allows the anonymization of persons involved in human trafficking activities, the avoidance of criminal prosecution, the removal of barriers regarding the location of traffickers/victims/consumers, as well as the favouring of crimes such as that of money laundering [18].

• *Monitoring and control phase* – digital technology is abused by human traffickers, including in monitoring and control activities of victims, so that criminal activity is uninterrupted, profitable, long-term. Victims are often exploited and blackmailed, including not being able to evade or bring to the attention of the authorities the criminal phenomenon that is ongoing. Existing data shows that traffickers also use the monitoring of victims' calls, phone records (manually or through spyware) and also video monitoring of victims (via social media apps on the phone or smart phone camcorders) [19].

• Research [20] shows that technology is preferred nowadays for a variety of reasons for all stages of exploitation, for a few key-reasons. The first one is anonymity and it allows traffickers to use the digital environment to create false identities on social media, fake profiles, encrypted communication and the dark web for recruitment of victims. Also, financial transactions (using cryptocurrency) maintain the anonymous character of the illicit operations. The second reason is that online platforms gather personal data and information which can be accessed through digital instruments by traffickers and enable the recruitment process of victims. Also, transportation and logistics can be organized as well, using the same profiles and platforms, anonymously. The third reason is that the online environment allows traffickers to easily expand their illicit operations, statistics showing that women (including young girls) comprise 94% of the victims who have been identified, at a global level. Finally, the ability to monitor and control the victims at all times is one more reason for traffickers to take advantage of certain technologies such as GPS software or video surveillance. This also allows for manipulation of the victims, gathering explicit content of them, using threats in case of domestic servitude and labour exploitation.

4. Smart technologies: tools for prevention and detection

Human trafficking is now experiencing new dimensions through the abuse of communication technology and the internet, leading to a new era in the whole human trafficking cycle, including the recruitment, exploitation and monitoring of victims, globally and independently of the location of both the main topics involved in trafficking in human beings and any other persons involved in the process. The COVID-19 pandemic has boosted human traffickers in relocating the means and tools they use to recruit and exploit victims online, leading to increased vulnerability of potential victims as well as increased clandestine character.

It is therefore now necessary to channel the attention of law enforcement, organizations and agencies at all levels (global, national, regional and local), both in order to prevent and combat trafficking in human beings and to support victims. Taking the necessary measures in this regard, using modern technologies, which are now abused by human traffickers against them, however, also requires a degree of involvement from states everywhere in ensuring respect for human rights, especially privacy. This can only be achieved through sound legislation, both at national and international level, a human rights oversight framework, the use of efficient technological tools and a strengthened exchange of information between all organizations involved in initiating activities aimed at combating trafficking in human beings.

While modern technology allows traffickers to adapt their way of working to facilitate the carrying out of activities specific to human trafficking, its use leaves, at the same time, certain digital traces that can be identified and used to prevent and combat the worrying phenomenon. The information obtained by the organizations involved in the process can be recorded, stored, analysed and, through effective information exchange, can lead to better management of intervention tools for preventing, detecting and combating organized crime in the area of human trafficking. Technologies are developing as law enforcement authorities seek to strengthen their technological capabilities and face new challenges, this puts even greater pressure on countries around the world to adapt legislative instruments to support judicial proceedings and prosecute human traffickers [21].

There are a variety of digital methods and tools that can be used to identify human trafficking activities, traffickers and people involved in various adjacent processes, including victims. Applications for smartphones and smart devices, analysis of online data and information, financial transactions operated by traffic participants (blockchain technology), facial recognition tools, artificial intelligence, investigative technology tools, strategies, digital forensics, the use of technologies to detect or support victims of human trafficking, these are some of the ways in which the phenomenon can be prevented and even revealed, in a more efficient way, provided that the responsibility of all states, institutions, organizations and agencies involved in combating trafficking in human beings is committed.

When resources at their disposal or even newly created resources are used efficiently, they allow the discovery of information relevant to authorities, in terms of the location of persons, identification data, structures involved, their role, in particular in organized crime

groups and activities undertaken as a result of trafficking. Digital evidence obtained using modern technology is becoming particularly important for the prosecution and prosecution of human traffickers, but can also be used as databases that can represent useful information exchanges across borders, it is an efficient and faster cooperation tool to combat the phenomenon.

The current legal system requires a number of changes to allow the collection and use of fingerprints to support criminal prosecutions. Countries around the world are encouraged to adopt key international legal instruments, international agreements such as the *Cybercrime Convention* [22] or the *Convention on mutual assistance in Criminal matters* [23], being considered as benchmarks in facilitating and strengthening international cooperation. Of course, in addition to updating the legislative instruments, it is necessary that human resources be made available and used effectively and that their technical knowledge be strengthened. The legislative framework should also be adapted to the category of persons providing internet and social services and who, by raising awareness of the abuse of technology of human traffickers, are encouraged to cooperate with law enforcement authorities, to provide valuable information and prevent traffickers from implementing online means of recruiting and exploiting victims.

Investments in the near future must be focused both on equipment supporting the development of effective investigative tools and on training human resources for the collection and handling of electronic evidence, including through the creation of technical support groups, specialized to be integrated into the investigation of trafficking in human beings.

Creating synergies between justice authorities, European-level organizations, European agencies and international bodies dedicated to preventing and combating trafficking in human beings, creating cooperation and support mechanisms through exchanges of relevant information and databases, including with the private sector, is a key tool in the process. Improved international cooperation in this area will facilitate the identification of both human traffickers and victims or potential victims more rapidly in the context of the development of secure electronic communication means, which will enable the actions taken by the States concerned to be more effective, as well as de-bureaucratizing the system and avoiding delays and errors that may occur during investigation.

Technology is one the main instruments to be used nowadays when approaching innovative solutions to tackle trafficking in human beings. The main reason is that internet is part of the everyday life for many people, globally. The dark site of the technology advances is that the internet has also become a great part of their activities for trafficking, in all stages: recruitment, exploitation and monitoring of the victims. In order to protect vulnerable people and victims, technology can become a great opportunity [24] for prevention, as well as detection. Technology can be used for many scopes, that go further that investigation and prosecution. Nowadays, the digital environment can also be leveraged for victim support and awareness-raising campaigns.

Detection, prevention and collaboration between stakeholders is essential when approaching trafficking by means of technological advancements.

In case of detection, approaching the fight against trafficking in human beings can be done through the following instruments and methods [25]:

- *Artificial Intelligence (AI), data analysis, monitoring platforms* – trafficking patterns can be analysed with the help of AI, from online activity to financial transactions. By using online monitoring platforms and algorithms, suspicious activities (such as grooming, adds and job offers) can be scanned and traced. The dark web can also be monitored, since it is a common place to operate anonymously and perform illicit activities;
- *Victim identification* – many explicit content is uploaded in the online space, which means that photos and videos of victims can be scanned through facial recognition software, in order to match persons with these. Often, missing people can be identified, and even location, with the help of image geo-tagging;
- *Cryptocurrency tracking* – financial transactions for illegal activities are often made via cryptocurrencies. Trafficking networks are formed this way and they can be uncovered with blockchain analysis tools which are able to trace these financial transactions;
- *Digital forensics* – confiscated devices can be analysed by law enforcement using the latest technology developments to get access to encrypted communication or transaction logs etc.

In case of prevention, approaching the fight against trafficking in human beings can be done through the following instruments and methods:

- *Raising awareness* – dedicated campaigns can be elaborated and disseminated through social media platforms in order to educate the population, including the vulnerable categories, regarding the risks and modus operandi of traffickers in the digital age. Also, in the scope of education, interactive e-learning modules can be used to show ways to be able to recognize and report suspicious cases;
- *Protection* – All individuals, including vulnerable groups can have access to safety apps, in case they are at-risk. Also, to protect vulnerable categories, online platforms should be able to analyse and identify possible job offer scams, targeted ads (especially for migrants and young categories).

In case of collaboration and coordination measures [26], approaching the fight against trafficking in human beings can be done through the following instruments and methods:

- *Sharing information* – Tools that allowing data sharing between several actors from different backgrounds, from law enforcement, agencies to NGOs and private companies can be useful for both tracking networks and individuals and also for generating alerts, including for victims or suspicious activities;
- *Partnerships* – Monitoring uploaded content can be done with the help of technology, if partnerships are created between social media companies and authorities. Crowdsourcing intelligence can also be used to identify locations from explicit content materials uploaded, using platforms which allow users to contribute with ideas and photos.

4.1. Impact of COVID-19: acceleration of digital trafficking channels

The COVID-19 pandemic affected everyone's lives, globally. People around the world were faced with unprecedented measures during the pandemic, which reshaped societies,

exacerbated the authorities' and law enforcements' vulnerabilities and transformed the fight against crime into an even more complicated process than in normal conditions. The imposed quarantine and lockdowns for a long period of time, the travel restrictions and economic shutdowns directly impacted citizens' lifestyle, as well as the capacities of the authorities at all levels to protect them, especially the vulnerable categories, from becoming victims of different types of trafficking. The new way of living as we all knew it not long ago, also brought changes in the business models of traffickers, who started to use and abuse modern technologies and the online world for their scopes.

Many individuals faced serious consequences such as losing their jobs and not being able to take care and provide for their families [27]. These situations affected especially the informal and low-wage sectors, causing economic insecurities for vulnerable citizens and forcing them to find new ways of bringing an income home, increasing their susceptibility to exploitation. This resulted into people searching for attractive job offers online, for example, which is one of the ways traffickers used to recruit their victims using digital platforms by means of fake job offers, social media grooming, false romantic relationships via dating apps or social platforms, as well as by gathering information of personal data, including financial struggles, family situations and offering assistance. Other ways include online gaming platforms which enable the players with the possibility to chat and build relationships and lead to manipulation of the victims, and even online blackmail in order to get victims to perform various activities related to trafficking.

The COVID-19 pandemic created a *safe environment* for traffickers, meaning that they were able to display their activities in plain sight, keep their anonymity and made it quite difficult for authorities, NGOs and law enforcement to prevent trafficking, detect suspicious activities and protect vulnerable citizens and victims.

Another direct impact of the COVID-19 measures was on the young generations, who faced school closures and increased the risk of exploitation. For many children, school represented a safe place, as well as the main source of education, shelter and food. In the absence of these, in some countries, children were forced to be on the streets, increasing not only the risk of infection, but also the risk of becoming victims of traffickers. Online abuse increased, as unsafe environments were created in the digital space, allowing traffickers to easily contact them, recruit them and use the information received to demand explicit content and blackmail them in case of not receiving the material they were searching for. Domestic abuse had also increased during the pandemic, as lockdowns and limited movement were imposed, mainly for decreasing the risk of infection for citizens. The isolation of victims, especially those who were still in confinement by the traffickers, represented serious threats to women and children. Identification of victims was also a difficult job to do for NGOs, who can normally provide shelter and protection measures for those in need. Mental health issues can become a challenge due to isolation and worsened living conditions caused by state restrictions.

In case of seasonal workers and migrants, the risk of being more vulnerable to exploitation also increased. The inability to renew their travelling and working documents due to closed public services and borders made it difficult for these vulnerable categories and increased

exploitation risks (e.g. forced labour, improper working and living conditions), while also affecting their access to healthcare and social benefits.

In response to unprecedented measures and direct consequences for people around the world, The United Nations Office on Drugs and Crime (UNODC) provided several studies and tried to address these emerging challenges through a variety of initiatives such as new tools to assess the pandemic's impact on anti-trafficking efforts, financial support for NGOs in order to be able to continue to assist identified victims, protective equipment delivered to law enforcement to ensure safe interactions with victims, as well as providing free eLearning courses related to anti-trafficking in a series of languages [28].

Other studies have analysed the rapid digitalization of trafficking networks during the pandemic, showcasing that traffickers quickly adapted to online platforms, finding that the digital world was a key enabler for criminal activities. Recruitment stages, grooming and exploitation were performed while maintaining anonymity, while controlling and exploiting victims were happening even in the physical absence of traffickers. Findings show that there is a lack of international coordination in combating online trafficking and that a possible future solution would be creating a robust instrument for monitoring high-risk platforms. Other proposed measures include stronger legal frameworks for ensuring accountability for online platforms and also the need to promote public-private partnerships for ensuring proper victim protection [29].

One interesting approach of the profound impact of the COVID-19 pandemic on individuals is presented by researchers showing that the pandemic exacerbated existing social inequalities, which led to many people becoming vulnerable in the face of modern slavery and human trafficking. The study uses a series of methods to map risks, resilience factors and casual pathways to harm and characterizes the pandemic as a syndemic event. This means that the healthcare crisis exacerbated vulnerabilities of people who were directly impacted by movement restrictions, economic crisis and social isolation.

Mitigating harm proved to be difficult in such conditions but in some cases, the local NGOs and survivor alliances quickly adapted to the new conditions and used technology to prevent potential victims to be recruited and exploited. Such measures were providing citizens with mobile phones and SIM cards in order to prevent isolation and digital exclusion, while also supporting access to education and work [30]. The effectiveness of these measures also depend on national policies. Finding show that despite community efforts, there is a high need for targeted interventions on behalf of national authorities, such as support for personal income, safe housing, improvement in the educational field and access to jobs for at-risk population. The coordination needs to be multi-sectorial and involve systems leaders, policymakers as well as community organizations.

4.2. Case studies and emerging technologies in action

Twenty years after the adoption of the Palermo Protocol (2000), the States Parties involved in the prevention and combating of trafficking in human beings and in the process of supporting victims, including their reintegration into society, are currently facing numerous

challenges related to the ever-growing phenomenon and full implementation of the Protocol provisions.

At European Union level, but also at international level, in order for the efforts of States to reach the proposed objectives, it is necessary that the proposed and implemented cooperation mechanisms be carried out at all levels (local, regional, national and international) and involve a variety of relevant actors, including both public and private sector. The multi-level cooperation of all relevant actors, from a variety of sectors, is a successful governance mechanism, which must also be implemented in the field of preventing and combating trafficking in human beings. It is currently noted that many countries in Europe have entered into operational agreements with agencies such as Europol, Interpol or Eurojust, implementing the mechanisms made available by them, such as Joint Investigation Teams [31].

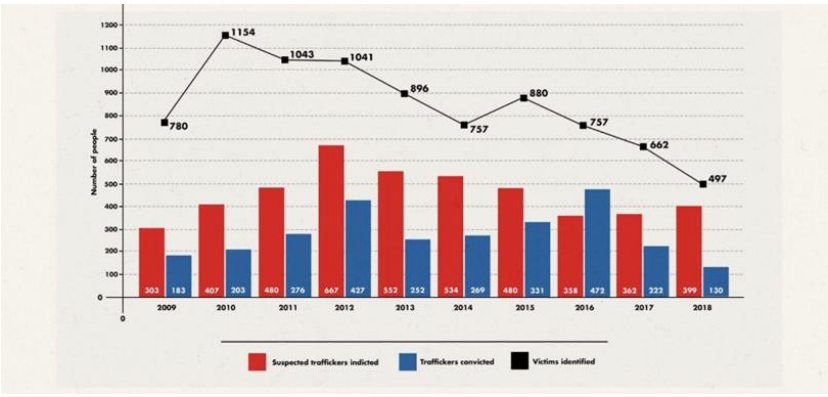

Fig. 3. Romania's record of fighting trafficking
Source: Blind Justice for Romania's Trafficked Roma Children, https://balkaninsight.com/2019/12/11/blind-justice-for-romanias-trafficked-roma-children/

Currently, Romania is making considerable efforts to advance in the fight against human trafficking, both in terms of amending the criminal legislation, increasing the number of prosecutions, convictions and even through cooperation with a non-governmental organization, through a pilot project, dedicated to helping and protecting victims of human trafficking. At the level of DIICOT (Directorate for the investigation of organized crime and Terrorism), in 2021 an anti-trafficking structure was established, which has as its attributions both the prosecution of human trafficking crimes and the provision of support and training for the regional offices of DIICOT [32]. Romania's efforts are aimed at combating the phenomenon of human trafficking, including by continuing to implement the National Anti-Trafficking Action Plan (2021-2022), but additional measures are needed in all sectors (prevention, combating and victim assistance).

Online solutions such as blockchain technology, artificial intelligence or face recognition software are innovative instruments that enable law enforcement agencies, non-governmental organizations and technology companies to approach the fight against trafficking in human beings. Smart collaboration between these actors is key to effectively approach trafficking in the digital age. By bringing together innovative technology tools

from technology companies, expertise and guidance from law enforcement agencies and support from NGOs, significant changes can be achieved for both prevention and detection of trafficking online.

There are several leading programs and their results can be capitalized in the future, such as Tech Against Trafficking (TAT) [33], which is a work stream of Global Business Coalition Against Human Trafficking (GBCAT). The coalition was launched in 2018 and it is comprised of several big technology companies that share expertise and work together with other relevant stakeholders (academics, experts, non-profits and other companies) to support the fight against trafficking and promote the use of technology solutions. The coalition's activities include *mapping the landscape* of existing technologies across geographies and target populations - such as vulnerable groups, survivors, law enforcement, and civil society. Also, it *identifies and selects* tools with the potential to scale and fosters innovative partnerships for greater impact. By *accelerating solutions*, TAT provides resources and support to scalable technologies, piloting and measuring their success while cultivating a supportive ecosystem. Additionally, TAT addresses *tech-facilitated trafficking* by sharing industry best practices, enhancing internal awareness, and driving improvements in technology-driven anti-trafficking strategies.

At European level, according to the statistics currently available, 14,311 victims of trafficking in human beings were recorded in the period 2019-2020 [34], but this only reflects the number of people officially identified as victims by responsible entities. In 2020, there were 6 534 victims in the European Union, a decrease of 16% compared to 2019 statistics [35]. However, in the light of recent developments in recent years that fall within the new digital dimension in the recruitment of victims and trafficking-specific activities, the European Commission has submitted a proposal to the European Parliament and the Council on strengthening measures to combat trafficking in human beings, By adapting the provisions on issues such as '*explicit reference to trafficking in human beings committed or facilitated through information and communication technologies, including internet and social media' or 'annual EU-wide collection of data on human trafficking will be published by Eurostat'* [36]. This new proposal comes in support of cooperation between the Member States of the European Union, whose primary responsibility is to eradicate trafficking in human beings. Member States cooperate in this field both through EMPACT (European multidisciplinary platform against criminal threats) and through EU-level agencies (Europol, Frontex, Eurojust), which support their actions to combat the phenomenon [37].

Cooperation between Member States and agencies at European level is also currently being promoted by the Network of Justice and Home Affairs agencies (JHA) by implementing the provisions of a joint declaration of commitment to collaboration against trafficking in human beings [38], Which is reflected in the information presented in the Network report [39], corresponding to their activities in the field of victim identification and protection, directly responding to key actions of the European Union Strategy against Trafficking in Human beings 2021-2025 [40]. The report underlines the particularly important role that European agencies play in the area of anti-trafficking activities, so as to encourage member

states to work closely with them, in particular on the identification, protection and assistance of victims.

According to a recent GRETA report [41], several countries in Europe have used technology in their fight against trafficking in human beings, such as North Macedonia, Germany of the Republic of Moldova. In North Macedonia, law enforcement agencies detected and dismantled trafficking networks by monitoring and analysing online platforms that displayed fake job advertisements. In Germany, authorities paired with tech companies and used digital forensics in order to be able to identify offenders who made use of dating apps and social media platforms to recruit their victims. In the Republic of Moldova, prevention measures were taken by La Strada, the NGO that provided support and assistance to victims and vulnerable potential categories of individuals. Through information and support, timely interventions can protect citizens from exposure to trafficking activities. Moreover, according to the same study, Facebook and IBM created a partnership in order to develop advanced algorithms to uncover accounts and activities associated with trafficking networks.

WeProtect Global Alliance is a global movement, launched as an independent organisation in 2020 that wants to transform the fight against child abuse, both physical and online. The alliance comprises a number of 103 governments, 76 private sector companies, 121 civil society organizations and 10 intergovernmental organisations. All the different relevant actors are brought together as a public-private partnership to elaborate innovative solutions to combat the illicit child trafficking. The initiatives came from the European Comission and US Department of Justice's Global Alliance Against Child Sexual Abuse Online and WePROTECT (UK), the global multi-stakeholder response created to combat online child sexual abuse [42].

The most recent example of collaborative approach to tackle human trafficking is the European Multidisciplinary Platform Against Criminal Threats (EMPACT) Hackathon 2024. The approach combines international collaboration with innovative technology and brought together 27 countries (including Romania) and 76 of their experts for a cross-border collaboration initiative focusing on countering trafficking operations via online platforms. The intensive operation was designed to detect and track online activities that are linked to trafficking networks. These activities resulted in the 252 entities checked, 40 online platforms checked, 16 suspected human traffickers detected, 60 potential victims of human trafficking identified [43]. Cutting-edge tools and instruments and global cooperation are key for smart states tackling human trafficking. The EMPACT Hackathon has set a precedent for future initiatives, at European and global level.

4.3. Legal and policy frameworks for smart cities

Countries around the world face challenges in terms of the alarming phenomenon of human trafficking, given that it is the fastest-growing criminal industry in the world and one of the most serious human rights violations. Stopping human trafficking is an ideal for all, but the reality we live in today shows that there are many steps to be taken before we get to the eradication of the phenomenon. In view of its rapid development, it is necessary to focus our efforts at all levels on preventing trafficking in human beings, developing action plans

and strategies, both individually, as states and jointly, at European and international level, to combat the phenomenon, support victims and reintegrate them into society. Strengthening partnerships and improving cooperation and coordination between the various international organizations active in preventing and combating trafficking in human beings and protecting its victims are key elements in this process.

At international level, we find a variety of instruments containing rules and practical measures to combat the exploitation of persons, with victims of women and children at the heart of their concerns. Over time, it has been concluded that a universal instrument addressing all aspects of human trafficking is necessary, including the need for a coherent and common international approach to prevent, combat and protect victims of trafficking in human beings. In 2000, the *Protocol to Prevent, Suppress and Punish Trafficking in Persons, especially Women and Children*, was adopted, complementing the United Nations Convention against Transnational organized crime. It entered into force in 2003 and is currently ratified by 180 States Parties around the world. Cooperation between States Parties is one of the objectives of the Protocol, together with the prevention and combating of trafficking in human beings and the protection and assistance of its victims, in view of full respect for human rights.

According to the key provisions of the Protocol, *"law enforcement agencies in the countries ratifying the Protocol should cooperate with each other in identifying criminals and trafficked persons; exchanging information on the methods of criminals; and training investigators, law enforcement personnel and victim support staff. The Parties should also implement security measures and border controls to detect and prevent traffic. These include strengthening their own border controls; imposing requirements on commercial carriers to verify passports and visas; setting standards for the technical quality of passports and other travel documents; and cooperating in establishing the validity of their own documents when used abroad"* [9].

The implementation of the measures and provisions of the Protocol has proved to be a complicated process, given the variable implementation capacity of States Parties to develop effective and multidisciplinary strategies to combat trafficking in human beings, despite their efforts to make changes to the legislative and institutional framework necessary to achieve these objectives. For this reason, almost 10 years after the adoption of the Protocol, it was necessary to develop and adopt an International Framework of Action for the implementation of the Protocol on Trafficking in persons (2009), which identifies the challenges faced by States in their efforts to prevent and combat trafficking in human beings, supporting the victims. These challenges lie in the following four areas: limited financial resources; knowledge and research; capacity building and development; monitoring and evaluation [44].

The International Framework of Action is based on a set of principles formulated to support the implementation of the Protocol on the Prevention, Suppression and punishment of Trafficking in persons, especially Women and children, by States Parties, and an elaborate guide, focusing on five main pillars of intervention (prosecution, protection, prevention, prevention, control of trafficking in human beings). National and international coordination

and cooperation), considered essential for combating trafficking in human beings. There are also clear instructions on the provisions of the Protocol, specific objectives, indicators, implementation measures and resources to be used to achieve the proposed objectives.

Also, one of the valuable cooperation instruments adopted in the field of combating trafficking in human beings, a treaty binding on the parties, is the Council of Europe Convention on the fight against trafficking in human beings (adopted in 2005; in force since 2008), ratified by 48 parties at present [45]. The Convention contains a set of measures considered minimum for preventing trafficking in human beings, prosecuting those responsible and protecting and assisting victims, who are being infringed on their human rights, dignity and integrity as human beings. The Convention also promotes international cooperation in all aspects related to combating trafficking in human beings. The implementation of the provisions of the Convention is monitored by the Group of experts on Action against Trafficking in persons (GRETA), which regularly reports, after each monitoring round, its conclusions on the implementation of the provisions of the Convention, based on the development of a questionnaire for the countries assessed and on-site visits, together with its recommendations, including on the basis of information received from non-governmental organizations within the countries assessed [46].

5. Conclusion and future directions

The problem of human rights violations and fundamental freedoms at global level has developed, mainly as a result of the phenomenon of slavery. This has led to the adoption of specific human rights legislation and the establishment of bodies and agencies to promote the importance of respecting them and condemning all persons and actions against these fundamental values.

The right to life, the right to freedom (including freedom of movement), the right to security, the right not to be subjected to slavery, torture, forced labour or other inhuman and degrading treatment are just some of the fundamental rights of people, which are affected by the existence of human trafficking, at international level. Many of the victims resulting from trafficking in human beings do not have the necessary assistance and protection, which often lie in the hands of the governments of the states from which they come, whose policies are generally in the hands of the governments of the states from which they are based. More aimed at identifying and prosecuting traffickers and people involved in the trial, at the expense of supporting victims. This represents a new form of human rights violation, which can often lead to greater vulnerability of victims, including situations of re-victimization.

Human trafficking has increasingly adapted to the digital age, presenting new challenges and both opportunities for prevention, detection, and prosecution. As this paper illustrates, traffickers exploit online platforms and technological tools to expand their reach and efficiency. However, these same technologies offer unparalleled opportunities to combat this heinous crime effectively. The integration of artificial intelligence, blockchain technology, and digital forensics has shown promise in disrupting trafficking networks, identifying victims, and tracing illicit activities. Initiatives like the EMPACT Hackathon highlight the impact of international collaboration and cutting-edge tools in addressing

trafficking on a global scale. Similarly, partnerships between public and private entities have fostered innovation in prevention and victim support.

To fully leverage the potential of technology, governments must prioritize robust legal frameworks that address the complexities of tech-facilitated trafficking. Enhancing cooperation among law enforcement, NGOs, and technology providers is critical to ensure resources are effectively mobilized. Awareness campaigns and digital literacy programs for vulnerable populations can further reduce the risks of exploitation.The COVID-19 pandemic underscored the adaptability of traffickers and the importance of proactive measures to safeguard at-risk individuals. As society becomes increasingly interconnected, it is imperative to maintain vigilance in the online sphere and continuously innovate anti-trafficking strategies.By embracing technology as a tool for justice and humanity, stakeholders can not only dismantle trafficking operations but also create a safer digital and physical world. This requires unwavering commitment from policymakers, tech innovators, and civil society, united by the common goal of eradicating human trafficking and upholding the dignity and freedom of all individuals.

The COVID-19 pandemic was considered a favourable moment for the phenomenon of trafficking in human beings, in particular in terms of adapting the means of recruitment of victims, taking advantage of their vulnerability due to isolation, economic crisis, inequality and the use of the internet and technology as the main means of communication and working method. These changes have focused attention on new methods of recruiting, exploiting and monitoring potential victims/victims of human trafficking, by integrating technology into the way traffickers work. Thus, the specific activities of the phenomenon can be carried out clandestinely, but also outside any geographical barriers. In order to protect people at risk of becoming victims of human trafficking, the online environment needs to be made safe again and the technology used to combat human trafficking and the negative effects it generates.

The present moment must be seen as an opportunity to use the power of technology to prevent human trafficking. Prevention must be supported mainly by actions to strengthen legal instruments, in the context of the need to adapt to current developments in the area of trafficking in human beings. Actions to prevent trafficking in human beings, victimization and re-victimization also include:

- actions to increase the detection of technology-facilitated traffic to human beings;
- training courses for prosecutors on facilitated technology trafficking of human beings and the handling of electronic evidence;
- actions to strengthen cooperation with private enterprises (cooperation protocols, data sharing procedures);
- cross-cutting actions (states must include a technological strategy in their national action plans to combat trafficking in human beings);
- actions to protect and support victims (ex: Love Justice International – a civil society organization funded by UNVTF, which aims to identify potential victims in the process of recruitment for human trafficking, but before they are exploited.

“As part of the 2023 future Summit, we proposed a global digital pact to rally the world around the need to bring good governance into the digital space” [47]. At this time, the statement of the Secretary-General of the United Nations, António Guterres, appears in the context of the need for cooperation between all relevant actors, including state governments, businesses, non-governmental organizations and civil society, to develop the necessary technology-based policies and legislation, to support victims of human trafficking and to be effective mechanisms for preventing the phenomenon. Collaboration at all levels is becoming essential both in combating the phenomenon and in promoting respect for the fundamental rights and freedoms of people everywhere.

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A safer Europe with smart information systems for border and security: SIS II&VIS

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Abstract
Schengen Area remains among the most emblematic achievements of European integration, as the border-free area it guarantees free movement for more than 425 million EU citizens. On the 31-st of March 2024, Romania became the newest Schengen Member State. Romania plays a key role in contributing to the well-functioning of the Schengen area, in securing the EU's external border. Romania has been progressively implementing the Schengen legal framework, including the second generation Schengen Information System (SIS II) and Visa Information System (VIS). SIS II is a tool used by security officials to help keep people crossing borders safe, it is the most widely used IT system for security and border management in Europe. VIS supports the implementation of the EU's common visa policy and facilitates border checks. In order to make the dedicated audience aware of the recent security challenges, our paper is progressively describing how the above information systems are operational managed by the European Union Agency for the Operational Management of Large-Scale IT Systems/eu -LISA - in the Area of Freedom, Security and Justice. The second main endeavor of the paper is to offer very specific details related to security issues on the mission taken by eu-LISA of assisting - daily 24/7- Member States to create a safer Europe through the use of state-of-the-art technological solutions. Last but not least, the paper envisages a global view with the systems currently managed by eu-LISA and the process of developing new systems (EES, ETIAS, ECRIS-TCN), along with their interoperability components.

Keywords: Smart Governance, Interoperability, Border Security, Smart Mobility, Smart Technology.

1. Introduction
Schengen Agreement was signed in 14 June 1985; five years later, in 19 June 1990, Schengen Implementing Convention was signed and it entered into force, five years later, on 25 March 1995. Initially, the Schengen implementing Convention (signed only by Belgium, France, Germany, Luxembourg and the Netherlands) was based on *intergovernmental cooperation in the field of justice and home affairs.* Today, the Schengen Area [1] - "the largest area of free movement in the world" - consists of 29 European countries of which 25 are EU states: Belgium, Czech Republic, Denmark, Germany, Estonia, Greece, Spain, France, Italy, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Slovenia, Slovakia, Finland and Sweden, Croatia, Bulgaria, Romania, along with 4 Schengen Associated Countries: Iceland, Liechtenstein, Norway and Switzerland.

Today the Schengen Area offers the picture of an EU successful model for creating a common *area of freedom, security and justice*; the right of *free movement* when travelling becomes guaranteed within an Europe without internal border controls, with unrestricted travel, where borders remain only on the map. Schengen States must respect a set of common Schengen rules consisting in: adhering to the *Schengen acquis*; managing external borders on behalf of the Schengen zone; issuing uniform Schengen visas by using *Visa Information System: VIS*; effectively participating in law enforcement cooperation by using

Schengen Information System: SIS - "the cornerstone of law enforcement Schengen cooperation".

Since 2012, the European Union Agency for the Operational Management of Large-Scale IT Systems in the Area of Freedom, Security and Justice - eu-LISA [2] is providing long-term solutions for the management of IT - large scale systems, essential pieces for keeping EU citizens safe within the EU's borders, among them: Schengen Information System/SIS and Visa Information System (VIS). Over the last decade, eu-LISA broadened the scope of its work on research and innovation. Today, the Agency is managing and developing numerous IT systems envisaged as essential cornerstones for the smooth functioning of the Schengen Area. At the EU's external borders IT-large scale systems ensure the efficiency of the border control and the implementation of the EU migration, asylum and visa policies [3].

2. The legal framework

The European Union Agency for the Operational Management of Large-Scale IT Systems in the Area of Freedom, Security and Justice: eu-LISA, commonly known as "The Digital Heart of Schengen" was born by Establishing Regulation (EU) No 1077/2011 "in order to ensure the operational management of SIS, the VIS and Eurodac and of certain aspects of their communication infrastructures and potentially that of other large-scale IT systems in the area of freedom, security and justice". In 2018 eu-LISA was given a larger mandate by the Regulation (EU) 2018/1726 [4] which stated that "the core function of the Agency should continue to be the fulfilment of the operational management tasks for SIS II, the VIS". The headquarter of eu-LISA was established in Tallinn (Estonia), its operational center is in Strasbourg (France) dealing with tasks relating to the technical development and the operational management of large-scale IT systems in the area of freedom, security and justice; in addition, there is a backup site for those systems under management based in Sankt Johann im Pongau (Austria) and a Liaison Office in Brussels (Belgium).

According with eu-LISA established objectives: "Without prejudice to the respective responsibilities of the Commission and of the Member States under the Union legal acts governing large-scale IT systems, the Agency shall ensure:

(a) the development of large-scale IT systems using an adequate project management structure for efficiently developing such systems;

(b) the effective, secure and continuous operation of large-scale IT systems;

(c) the efficient and financially accountable management of large-scale IT systems;

(d) an adequately high quality of service for users of large-scale IT systems;

(e) continuity and uninterrupted service;

(f) a high level of data protection, in accordance with Union data protection law, including specific provisions for each large-scale IT system;

(g) an appropriate level of data and physical security, in accordance with the applicable rules, including specific provisions for each large-scale IT system [4]."

Eu-LISA started its activities on 1 December 2012, thus "the Agency took over the tasks conferred on the Management Authority in relation to the VIS by Regulation (EC) No

767/2008"; later, on April 2013, "the Agency also took over the tasks conferred on the Management Authority in relation to SIS II by Regulation (EC) No 1987/2006".

"In relation to SIS II, the Agency shall perform:
(a) the tasks conferred on the Management Authority by Regulation (EC) No 1987/2006 and Decision 2007/533/JHA; and
(b) tasks relating to training on the technical use of SIS II, in particular for SIRENE staff (SIRENE — Supplementary Information Request at the National Entries), and training of experts on the technical aspects of SIS II in the framework of Schengen evaluation [4]."

"In relation to the VIS, the Agency shall perform:
(a) the tasks conferred on the Management Authority by Regulation (EC) No 767/2008 and Decision 2008/633/JHA; and
(b) tasks relating to training on the technical use of the VIS and training of experts on the technical aspects of the VIS in the framework of Schengen evaluation [4]."

"Operational management of Central SIS II shall consist of all the tasks necessary to keep Central SIS II functioning 24 hours a day, 7 days a week in accordance with this Regulation, in particular the maintenance work and technical developments necessary for the smooth running of the system [5]."

"Operational management of the VIS shall consist of all the tasks necessary to keep the VIS functioning 24 hours a day, seven days a week in accordance with this Regulation, in particular the maintenance work and technical developments necessary to ensure that the system functions at a satisfactory level of operational quality, in particular as regards the time required for interrogation of the central database by consular posts, which should be as short as possible [6]."

3. Overview on SIS and VIS IT systems in the area managed by eu- LISA

The Schengen Information System/SIS is the EU's largest and most widely used *information-sharing system*, it facilitates free movement of people within the Schengen area by offering essential support for managing Schengen's external borders, ensuring a high level of internal security and contributing to law enforcement and judicial cooperation across Europe increasing operational cooperation between national competent authorities (border guards, police, SIRENE Bureaux, judicial, customs and immigration authorities). SIS II enables competent authorities to enter and to consult data it facilitates as well as the exchange of information on persons and objects between European national law enforcement and judicial authorities.

As parts of eu-LISA's SIS legal reporting obligations, a list of the competent authorities authorised to search the system directly and a list of SIRENE Bureaux are published annually in the *Official Journal of the European Union*. Since August 2023, eu-LISA maintains a continuously updated list of authorities on its website; annually eu-LISA is publishing a *Report on the technical functioning of central SIS II* [7] which encompasses all activities that contribute to the operational management of the central SIS II, (including security, data protection and statistics for reporting years).

Eu-LISA is responsible for the operational management of central SIS II, ensuring uninterrupted 24/7 access to the system and allowing the continuous exchange of data between the national authorities, in accordance with the legal provisions. The operational management includes: management services, supervision and the implementation of appropriate corrective, adaptive and evolutionary maintenance [2].

The Visa Information System/VIS is an indispensable part of the Schengen acquis, being the technical solution of connecting Member States and consulates in non-EU countries with all external Schengen border-crossing points. VIS deployment phases began in 2011 and the system has been operational worldwide since February 2016. The system streamlines visa verification at external border-crossing points and facilitates the work of the Member States' consular authorities in managing visa applications for entering and transiting the Schengen Area.

VIS consists of the Central VIS (CS-VIS), the Backup Central Unit (BCU), a national interface (NI-VIS) in each Member State connected to VIS, and the communication infrastructure (VIS mail). The CS-VIS includes the Biometric Matching System (BMS), which is a subordinate automated fingerprint identification system (AFIS) responsible for biometric operations entering into play depending on the specific VIS operation requested. The BMS allows Member States' border authorities to identify and verify, through fingerprints alone, third-country nationals holding a Schengen visa and travelling to the Schengen Area. The system simplifies visa application procedures, makes it easier to identify internal security threats, and prevents *visa shopping* fraud by storing a precise history of individuals' applications and decisions [8].

LISA is publishing every 2 years, as parts of Agency's legal reporting obligations, a report on the technical functioning of Visa Information System (VIS) [8], accordingly the report is submitted to the European Parliament, to the Council and to the Commission. LISA's *VIS Technical Report* covers the technical functioning of the VIS central system, providing an overview of operational management activities it also includes data provided by Member States on use of VIS.

Eu-LISA is responsible for the operational management of central system Central VIS (CS-VIS) and certain aspects of the communication infrastructure 24/7; eu-LISA is also responsible for the technological and functional development of the VIS central system. Developments and changes are analysed and formalised within the Demand Management Process, and then discussed and approved by the VIS Advisory Group [8].

3.1. Operational management of Central SIS II and VIS

The eu-LISA Management Board, together with the SIS II Advisory Group/SIS II AG, support the Agency on the issue. Eu-LISA shares responsibility for SIS II governance together with the European Commission, the Member States and several stakeholders. The Commission is responsible for the correct implementation of the SIS II legal framework and any legislative initiatives linked to the system. The Agency is responsible for the SIS II central system (CS-SIS), while the Member States are responsible for their

national systems (N.SIS). The SIS II Advisory Group comprises representatives from each Member State, a representative of the Commission and appointed observers from Europol, Eurojust and Frontex. This regular forum decides on changes to be endorsed and implementation of timelines and dependencies. The SIS II Advisory Group also reports on the availability of the central SIS II and national systems, approves release plans, discusses and plans developments, assesses training activities and adopts the annual statistics report [7].

The operational management of the Agency on VIS is done in close coordination with the Member States and the Commission. Each Member State is responsible for implementing, operating and managing its own national system. In performing the operational management of VIS, the Agency has been steered by the Management Board (MB) and the VIS Advisory Group (VIS AG). VIS AG has regular meetings, three or four times a year to discuss, among others, system availability and performance, the approval of proposed changes, and the release of future developments. VIS AG plays an important strategic role and provides the MB with expertise related to VIS.

The maintenance in working order (MWO) framework contract covers the provision of services related to corrective, adaptive, preventive, perfective and evolutive maintenance of the Central VIS, the BMS, the VIS Mail System, devices shared between VIS and SIS, and associated services and technical support to the Member States. eu-LISA is responsible for the operational management of the Central VIS and the BMS. Meanwhile, the MWO contractor is responsible for the performance of the system, any dysfunction or degradation in the performance of services, and complementary maintenance needed to overcome and solve such dysfunctions or degradations [8].

In July 2021, new Regulations revising VIS were adopted: Regulation (EU) 2021/1133, Regulation (EU) 2021/1134, (EU) 2021/1152. The new legal basis added a significant number of functionalities to the system, expanding its initial remit. Most importantly, the scope of the system was broadened to include *long-stay visas and residence permits* alongside the previous focus on *short - term visas*. This revision ensures interoperability with other relevant EU IT systems, most notably between VIS and Entry/Exit System/EES and between VIS and European Travel Information and Authorisation System ETIAS.

3.2. Technical infrastructure and the implementation of SIS Recast

For further enhance the effectiveness and efficiency of the Schengen Information System and to better tackle increasingly complex security challenges, major changes were foreseen for SIS II: In 2018 new Regulations on the establishment, operation and use of SIS were issued: Regulation (EU) 2018/1860, Regulation (EU) 2018/1861, Regulation (EU) 2018/1862. Since 2019 eu-LISA has been carried out on the implementation of SIS Recast regulations, being responsible for the communications infrastructure, the development of central SIS and the coordination of test campaigns with Member States and the EU agencies. In addition, eu-LISA discussed the progress of Recast with stakeholders regularly, including the SIS-SIRENE Committee, SIS II AG, the SIS II Expert Group and the Commission [2].

Without any doubt following this evolution SIS II usage has grown over the years, demonstrating the importance of proper maintenance taken by eu-LISA and evolution of the system; SIS II -'second generation' Schengen Information System - was operational from 9 April 2013 until 6 March 2023; on 7 March 2023, as a result of the joint efforts of eu-LISA, the Member States and the Commission SIS Recast entered into operation. The renewed system represents a major enhancement, with the main changes providing for new categories of data and alerts, and wider access to SIS alerts at national and European level [7].

3.3. Recent eu-LISA's projects implemented in SIS evolution: SIS II for AFIS, SIS Increase Capacity project, SIS II with ETIAS

The Agency worked on several projects in order to upgrade and ensure the proper maintenance of the system, together with the preparations for the entry into operation of SIS Recast: In March 2018, eu-LISA implemented the Automated Fingerprint Identification System (AFIS), for SIS II, introducing a biometric search capability at central level, allowing the identification of persons of interest solely based on their fingerprints. All Member States were required to enable SIS-AFIS searches at national level. In 2019, eu-LISA launched the SIS II AFIS Phase 2 project. In April 2019, the Agency launched the SIS Increase Capacity project, which introduced new technical, hardware and software components and also ensured that the system could handle a higher volume of alerts.

In 2022 eu-LISA started a project to interconnect SIS II with ETIAS and interoperability components. Meanwhile various other technical specific projects were carried out by eu-LISA as projects for replacing network equipment with more powerful and more maintainable devices, improving SIS test tools such as the National Systems Simulator (NSSIM), moving the SIS II backup service to eu-LISA's Common Service Infrastructure (CSI), upgrading AFIS Oracle Database to v19, replacing Disk Storage by deploying new more powerful hard disks [7].

3.4. Technical performance of VIS - in line with the service-level agreement

During 2022 – 2023 the overall technical performance of the VIS central system and BMS was in line with the service-level agreement (SLA). The availability of the VIS central system was 99.63% in 2022, and the response time performance indicator was 99.70%; in 2023 the availability indicator was 99.97% and the response time performance was 99.98% [8].

Eu-LISA was responsible for coordinating tests, determining test requirements, and planning. Before each release is deployed, extensive testing campaigns are carried out. The deployment and release activities are planned and carried out in such a way as to minimise the impact on the operational activities of the systems, with special attention paid to their performance and availability; eu-LISA supported the Member States in a variety of testing activities, ensuring that VIS functions properly, as required by the VIS Regulation.

In order to better support Member States, eu-LISA was focused on testing platforms, which went live in spring 2022, increased availability, reliability and agility for operational support, significantly improving incident resolution and service recovery time for the

benefit of all Member States. Central VIS monitoring is carried out at the operational centre in Strasbourg by the eu-LISA Service Desk, operational 24 hours a day, 7 days a week, a single point of contact through the Service Desk function, where users can report incidents and request for information or technical advice and support [8].

3.5. The Agency innovating VIS projects: Database migration to the CSI, Revised VIS project, VIS Interoperability project, Development of the sBMS, EU VAP

VIS continues to evolve and eu-LISA, together with the European Commission and the Member States, is managing numerous projects to fully integrate VIS in the new interoperability architecture for the Justice and Home Affairs Area/JHA, and to implement the new VIS Regulation adopted in July 2021.

In 2021 the Agency successfully migrated the VIS Business Database to the Common Shared Infrastructure (CSI); the CSI platform is a step in the direction of interoperability contributing to the more efficient and standardized use of infrastructure resources; the Agency also migrated the VIS Mail system onto the CSI.

The Revised VIS Regulation requires significant changes to both the business processes and central system. At the beginning of 2022, eu-LISA launched two projects towards the system's update according to the new legislation (Revised VIS Regulation): the Revised VIS project and VIS Interoperability. In June 2022, the Management Board invited the Agency to explore the possibility for closer integration of the timeline for the implementation of VIS Recast into the overall Interoperability timeline. In September 2023, the VIS AG adopted the opinion recommending merging the Revised VIS and VIS-IO programs. As part of the Revised VIS project, the system is being redesigned to accommodate for functions such as *long-stay visas and residence permits.* In the first few months following the launch of the project, eu-LISA took stock of the requirements and prepared the business use cases. By October 2022, the Interface Control Document (ICD) was prepared together with the Member States and the Commission [8].

The VIS Interoperability project was the second project launched in January 2022 and was subsequently merged with the Revised VIS project. The system is to be upgraded to ensure that it fulfils its critical role through its interoperability with other Justice and Home Affairs/JHA systems firstly with Entry-Exit System (EES) and the European Travel Information and Authorisation System (ETIAS), and later with the Schengen Information System (SIS), the European Criminal Records Information System – Third Country Nationals (ECRISTCN), European Dactyloscopy (Eurodac). VIS will also be connected Common Identity Repository (CIR), European Search Portal (ESP), Multiple Identity Detector (MID) and Central Repository for Reporting and Statistics (CRRS). VIS's integration with Interoperability components is set to be completed by the end of 2026. Similarly, eu-LISA started working to achieve VIS-ETIAS interoperability. To enable the simultaneous querying of VIS and the European Travel Information and Authorisation System (ETIAS), Interoperability connection will be established between VIS and the European search portal (ESP) [8].

In order to achieve interoperability, the BMS is set to be replaced by the shared Biometric Matching Service (sBMS). The sBMS will enable biometric data queries to be delivered across different Justice and Home Affairs/JHA information systems by sharing them in the Common Identity Repository (CIR). As such, it is one of the cornerstones of the EU's internal security and border management system, VIS will be the first system to use the sBMS once it is available. The VIS-sBMS functional integration was completed in 2022, and several tests were carried out in preparation for data migration.

In November 2023, the European Parliament and the Council adopted a Regulation on the rules to digitalize the Schengen visa procedure. Eu-LISA is tasked with the setting up and operation of the EU Visa Application Platform (EU VAP). All applications for Schengen visas will be made through this platform – including uploading relevant documents, and visa fee payments – which will forward them to the relevant national visa systems. Under the new rules, visas is issued in digital format as a cryptographically signed 2D barcode, replacing visa stickers. This will reduce security risks related to counterfeit and stolen visa stickers [8].

4. The Agency training on the technical use of the systems SIS and VIS

Eu-LISA provides training for relevant national authorities in the Member States and EU agencies on the technical use of all the large-scale IT-systems it manages, and the new upcoming systems, including interoperability components. Training sessions are organised as face-to-face events and via the Agency's e-Learning platform (online courses and webinars). The latter have grown considerably in the last years, becoming the main channel for training delivery [8].

According with Regulations rules eu-LISA is responsible for providing training on the technical use of the system to national SIS II operators, SIRENE staff and Schengen evaluators18. The training programme for national IT operators and technical SIS II experts facilitates the operational management of the system and supports technical maintenance, facilitates communication through the single point of contact (SPoC/Service Desk), and helps to ensure data consistency, synchronisation and quality [7].

5. New Regulations applied on security SIS and VIS systems and in their communication infrastructure

The communication infrastructure provides an encrypted virtual network dedicated to the exchange of data between central and national systems as well as between the authorities responsible for the exchange of supplementary information (SIRENE Bureaux). The SIS II communication infrastructure is a community under the European private secure network named Trans European Services for Telematics between Administrations — New Generation (TESTA-ng). The SIS II security framework relies on the core principles of security, confidentiality, integrity and availability. At central level, SIS II infrastructure and the communication network ensure that the system protects the information transmitted and stored. Communication with Member States is protected by multiple layers of encryption and by a network of security controls, comprising several layers of firewalls and integrity checks. The central SIS II is physically isolated from external networks, systems and the internet. In the event of technical failure, operations can be promptly switched over

to the backup site in Austria. Access to both systems is only granted to duly authorised staff, cleared to perform system administration activities based on established roles and responsibilities. The central SIS II, including the AFIS component, follows the security measures set out in the SIS security plan, which contains controlled measures following a risk assessment. The current security plan in place was adopted by eu-LISA's Management Board in March 2021 [7].

The Agency carried out continuous security and data protection activities ensuring adherence to the core principles of security, confidentiality, integrity and availability. The recommendations made by the The European Data Protection Supervisor EDPS are also being implemented. Looking to the future, eu-LISA remains strongly committed to keep the SIS central system operational around the clock, whilst ensuring the system's operational maintenance and further development as per the legal requirements. Eu-LISA has been responsible for VIS administrative tasks related to the communication infrastructure between the Central VIS and national interfaces since 30 June 2018 pursuant to the VIS Regulation, as amended by Article 61 of the EES Regulation25. Furthermore, Article 7 of the EES Regulation requires certain hardware and software components of the EES communication infrastructure to be shared with the VIS communication infrastructure [8].

The upgrade of the VIS communication infrastructure was completed in 2021, enabling the VIS communication infrastructure to have a capacity almost seven times higher than before, in order to support the entry into operation of EES and ETIAS [8]. Eu-LISA ensures the operational effectiveness of the security controls at VIS central level, and the continuous improvement of the security strategy, in line with the requirements of the VIS Regulation and relevant Commission Decisions relating to data protection and information security which remains a core element of all activities undertaken by eu-LISA. Furthermore, the Agency is a *centre of excellence* in the provision of IT services, emphasising the assurance of system and data security in all its activities.

6. Conclusions

Krum Garkov, 10 years Executive Director of eu-LISA (2012-2022) expressed in a few words, eu-LISA accomplishments in its continuous and changing work day by day challenged over its whole activity, on the occasion of the anniversary of 10 years of existence:

"Ten years have passed, and we are proud to have been working side by side with the Member States to make Europe a safer place, and to let the citizens of today and tomorrow live their lives safely in an area of Freedom, Security and Justice. We have been dedicated on a daily basis to developing and managing the large-scale IT systems essential for the implementation of asylum, border management and migration policies of the EU. Guided by our mission, we have been providing high-quality services and solutions, building trust amongst stakeholders and continuously aligning the capabilities of technology with the evolving needs of the Member States, all whilst growing as a centre of excellence, year by year. We are eu-LISA, we are the Digital Heart of Schengen. Today, we proudly celebrate 10 years of working for the Europeans of tomorrow. We are making IT happen [9]. "

The paper presentation had a difficult mission to extract relevant, essential and updated information from some huge data platforms; in the meantime the eu-LISA activity was illustrated in the light of operational management of SIS and VIS large-scale IT systems, of technical - IT specific content of this type of activity and its continous innovation; the paper as a whole has tried to integrate the entire presentation into an extended context that of eu -LISA Global Mission, as declared: "to support the EU and the Member States in their effort to keep Europe open and secure through advanced technology [2]."

The attempt to summarize eu-LISA global assets using data available for 2022 has to comprise: a good cooperation with all relevant parties involved: EU Member States and Associated Countries, EU Institutions - the Council of the EU, the European Commission, and the European Parliament, EU Agencies operating in the area of freedom, security and justice, international organizations, academia, research organizations, non-governmental organizations, media and stakeholders; this cooperation is reflected not only in the eu-LISA projects and activities but also in its preparing and tasting work done by their Annual Conferences and their industry Roundtables on the issue. In the same time at the 2022 year level, eu-LISA was managing and developing 6 six large-scale IT systems: the Schengen Information System (SIS), Visa Information System (VIS), Eurodac, eu-LISA is also developing the Entry/Exit System (EES), the European Travel Information Authorisation System (ETIAS) and the European Criminal Records Information System - Third-Country Nationals (ECRIS-TCN), all of them were being built in order to ensure Interoperability; The Agency was on the way of integrating e-CODEX into its portfolio; during its 10 years of activity 31 European countries were connected to the Large-Scale IT systems developed and managed centrally by eu-LISA; the Agency has on its disposal 6 Advisory Groups composed by national project managers from 27 Member States, 4 Associated Countries, EU institutions and Agencies and 5 Permanent Working Groups on Cooperation, Biometrics, AI, Carriers and Testing [9].

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The future of memory

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Abstract
Objectives:The future of memorials is a complex and evolving topic, reflecting changing societal values, technological advances, and cultural shifts. As traditional practices of commemoration decline, new approaches are emerging that respond to contemporary needs and preferences. This transformation is evident in various sectors, including the funeral, cemetery, and cremation industries, which are adapting to meet the demands of a more diverse and mobile society. The study aims to understand what memorials of the future will look like. The research is based on the ongoing doctoral study at the Doctoral School of Architecture at UAUIM, Divergent Memories - Nobody's Monuments, started in 2020, and on articles published in various publications, such as the journal Arhitectura 4-5 2023(706-707), where an article on the situation of communist monuments in Ukraine appeared. The approach of the paper was done by analyzing recent case studies, as well as past memorials, to understand the major changes that society is going through today. Careful observations were made on memorials, taking into account the way people today preserve one's memory in the virtual environment, as well as in the physical environment. The study is of interest to students, teachers and researchers, in understanding the future of memorials. For architects, the study represents a landmark, which can guide them in the design of monuments appropriate for the 21st century. Research indicates that there is a significant shift towards personalized and informal practices of commemoration, which are increasingly favored by the bereaved over traditional formal ceremonies. This trend highlights a growing desire for memorials that resonate on a personal level, allowing individuals to express their grief and memory in ways that feel authentic to them. The work raises the question of the memorials of the future and how they will look in the future. The theme has remained unexplored and represents an important opportunity to understand the perspectives of monuments within the modern era.

Keywords: Virtual, Internet within memory, Digital.

1. Introduction
The future of memorials is a complex and evolving subject, reflecting changing societal values, technological advances and cultural shifts. As traditional commemorative practices decline, new approaches are emerging that respond to contemporary needs and preferences. This transformation is evident in various sectors, including the funeral, cemetery and cremation industries, which are adapting to meet the demands of a more diverse and mobile society. Research indicates that there is a significant shift towards personalized and informal commemoration practices that are increasingly favored by mourners over traditional formal ceremonies. This trend highlights a growing desire for memorials that resonate on a personal level, allowing individuals to express their grief and remembrance in ways that feel authentic to them.

1.1. What are the monuments?
Monuments and memorials are an integral part of the urban space. These take various forms such as: war memorials, public statues, monumental buildings, squares, temples, memorial gardens, pyramids, cenotaphs, obelisks, stone circles, civic precincts and even parts of the city [1].

The word "monument" has its origin in the Latin term "monumentum". In Greek mythology, "Mnemosyne" is one of the titanids, the daughter of Gaia and Uranus [2].

"Mnemosyne" is the goddess of memory and is at the origin of the Greek word "mnemonic". The term denotes a memory aid or marker.

The term memorial is mainly used for built forms that commemorate people who died as a result of catastrophes or wars. Monuments and memorials, in addition to their commemorative purpose, also have political meanings, legitimizing those who built them. They can present a carefully chosen narrative that focuses on events or individuals, according to the ideology or desire of political elites. Thus, cultural memory is in the form of a discourse, shaped by political intentions.

Adolf Loos wrote that the only part of architecture that becomes art is memorial architecture, more specifically the tomb and the monument. According to him, this part of the architecture has no practical function [3].

The monuments have the following character:

- Plays an important role in defining national memory and identity;
- Monuments can have multiple interpretations;
- Monuments legitimize those who hold power;

2. Current trends

One of the most significant trends shaping the future of monuments is the integration of digital technologies in their conservation and interpretation. The evolution of digital reconstruction methodologies, especially in the context of virtual reality (VR) and augmented reality (AR), enables immersive experiences that can enhance public engagement with historic sites [4]. These technologies are especially valuable for sites that are difficult to access, either due to geographic constraints or physical limitations of visitors. By providing interactive experiences, these digital tools can broaden the audience for cultural heritage and stimulate interest in conservation efforts.

Moreover, the design of memorial spaces is undergoing a transformation, moving away from traditional static monuments to more dynamic and interactive commemorative landscapes. This shift reflects a growing desire for spaces that facilitate user interaction through sensory experiences such as touching and participating in commemorative actions [5]. The evolution of memorial design emphasizes the importance of creating environments that resonate with contemporary audiences, fostering a deeper connection with the narratives they represent.

Furthermore, the commercialization of cultural heritage presents both challenges and opportunities for the future of monuments. As heritage becomes increasingly marketable, there is a risk of diluting its meaning in favor of commercial interests. However, this trend also opens up avenues for funding and support for conservation efforts, provided ethical considerations are prioritized [6]. The balance between commercialization and authentic representation of cultural heritage will be crucial in shaping the future landscape of monuments.

The future of monuments increasingly relies on interdisciplinary collaboration between historians, archaeologists, artists and technologists. This collaborative approach not only enriches the understanding and representation of cultural heritage, but also promotes innovative solutions for the conservation and interpretation of monuments. As the complexities of cultural heritage management evolve, integrating diverse perspectives and expertise becomes essential to creating monuments that resonate with contemporary audiences while honoring historical narratives. One of the main benefits of interdisciplinary collaboration is the improvement of documentation and analysis through modern technologies.

For example, high-resolution images obtained by photogrammetry and laser scanning have revolutionized the way cultural heritage is recorded and analyzed [7]. These technologies facilitate the detailed documentation of complex features of artifacts and architectural elements, allowing historians and archaeologists to conduct more comprehensive studies. The collaborative efforts of technologists, who provide the necessary tools, and historians and archaeologists, who provide contextual insights, create a robust framework for understanding the significance of monuments in their historical and cultural contexts.

Moreover, the role of artists in this interdisciplinary dialogue cannot be exaggerated. Artists serve as muses of innovation, inspiring new ways of thinking about and engaging with cultural heritage [8]. Their creative insights can lead to the development of new narratives and interpretations that resonate with modern audiences. For example, the integration of artistic practices with scientific methodologies can generate hybrid forms of knowledge that challenge traditional boundaries and foster deeper connections between the public and the monuments they encounter [9]. This synergy not only enhances the aesthetic experience of the monuments, but also encourages critical engagement with the stories they tell. The potential for interdisciplinary collaboration extends beyond artistic documentation and interpretation; it also includes the development of new technologies that can be applied to the conservation of monuments.

Collaboration between artists and technologists can lead to the creation of software-dependent artworks that use cutting-edge technology to engage audiences in new ways [10]. Such projects can serve as platforms for public interaction, allowing communities to participate in ongoing dialogue around their cultural heritage. This participatory approach not only democratizes the narrative surrounding monuments, but also fosters a sense of ownership and responsibility among community members. In addition, the integration of various disciplines can address the ethical and social dimensions of monument creation and conservation.

As discussions about the representation of marginalized histories gain prominence, interdisciplinary teams can work together to ensure that monuments reflect a more inclusive narrative [11]. Bringing together historians, archaeologists, artists and technologists, these teams can collaboratively explore the complexities of identity and memory, creating monuments that honor diverse perspectives and experiences. In conclusion, advocating for interdisciplinary collaboration between historians, archaeologists, artists and technologists is crucial to shaping the future of monuments. This collaborative approach not only

improves the documentation and interpretation of cultural heritage, but also promotes innovative solutions that resonate with contemporary audiences. By embracing diverse perspectives and expertise, we can create monuments that not only commemorate the past, but also engage and inspire future generations.

3. Case studies

The use of 3D modeling and projection techniques provides a unique opportunity to interact with these historical figures in a manner that transcends traditional preservation methods. The Bamiyan Buddhas, which were destroyed in 2001, have become a focal point for discussions about how advanced technologies can be used to recreate and visualize lost cultural artifacts [12]. The use of 3D modeling and projection techniques provides a unique opportunity to interact with these historical figures in a manner that transcends traditional preservation methods.

Fig. 1. Bamiyan Buddha statue, Afghanistan
Source:Drawing Bogdan Oțelea

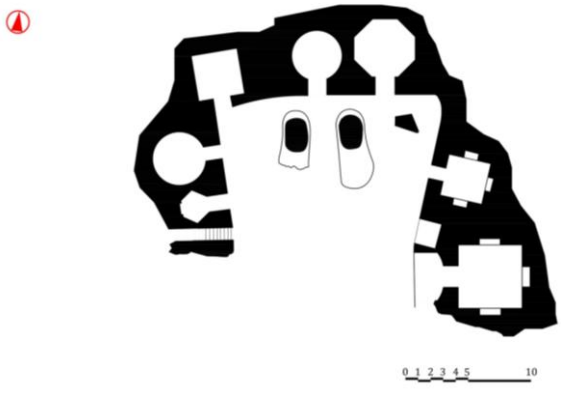

Fig. 2. Plan of the Bamiyan Buddha statue
Source:Drawing Bogdan Oțelea

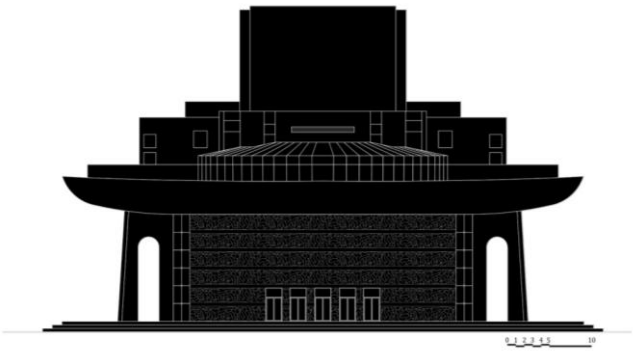

Fig. 3. The facade of the Bucharest National Theatre, on which a monumental fresco with the history of the country was provided. The fresco can be projected onto the facade without the need to paint it
Source:Drawing Bogdan Oțelea

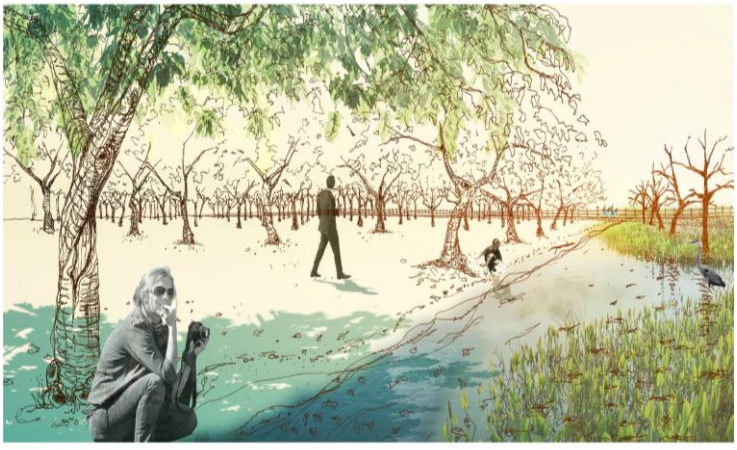

Fig. 4. Climate Chronograph
Source: https://terrene.co/designs/climate-chronograph

The Climate Chronograph, from the memorials of the future competition, gives a new vision of memorialization. Consisting of an observation deck and a garden, both at sea level, the memorial aims to mark the effects of global warming on the world. As the glaciers melt, the sea level will rise and slowly flood the garden. Thus, the process will be recorded in real time and the memorial will also become an observatory of global warming [13].

Compared to a contemporary memorial, such an approach means a use of perishable materials that can undergo changes according to future contexts. Such a monument will present different images throughout its life.

Studio Drift, a duo of Dutch artists propose the restoration of incomplete monuments, using illuminated drones. Their goal is to help architects visualize the design at full scale, without

the need for temporary structures or constructions. Such large-scale installations, using drones, can recreate the destroyed context of some monuments or memorials [14].

Fig. 5. The use of drones for the reconstruction of a monument
Source: https://www.domusweb.it/en/sustainable-cities/gallery/2022/11/03/studio-drifts-drones-illuminate-unfinished-monuments.html

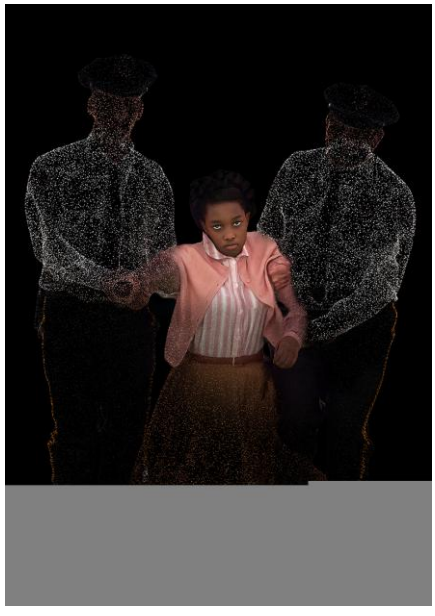

Fig. 6. The arrest of Claudette Colvin, captured in an installation at the Pompidou center. Claudette Colvin was arrested in 1950 in Montgomery, Louisiana for refusing to give up a seat on a bus to a white person
Source: https://www.centrepompidou.fr/fr/magazine/article/noire-grace-a-la-realite-augmentee-une-plongee-dans-lamerique-segregationniste

4. Future monuments

With the evolution of modern society, where a large part of the population uses the computer and the Internet, commemoration has moved from the physical world to the virtual one. The Internet offers vast possibilities for uploading images and songs that give the virtual environment a dynamic and expressive character. The use of pop culture and colloquial language gives it a vernacular character.

Virtual memorials facilitate interaction between people and become a therapeutic space through the opportunity for action and expression. Thus, charity sites offer help to certain causes, individuals or families of those affected, while commemorating a certain event.

A major advantage of these memorials is the wide spread of the message that can reach any point in the world. The fact that it is not physically constructed helps to adapt it to the present context.

Today's memory has reached a stage where the world's population shares a common consciousness. Different events in the world become the concern of everyone, in an effort to centralize. Media, culture and especially movies influence our perception of cultural boundaries. Films like Schindler's List turned the Holocaust into a tragedy known and accepted by people in countries around the world who had no connection to the events.

From author Alison Landsberg's perspective, the concept of prosthetic memory has no real basis, but functions as a genuine memory in American culture. The memory process arose as a result of the need to integrate into American society, immigrants who did not have an origin linked to the adoptive country. Migration to the new world overlapped with the emergence of new technologies, such as the cinema.

The most impactful pieces of a museum remain the authentic artifacts that have the power to break the dichotomy between the museum and the individual. Such artifacts are present in museums around the world, such as transport wagons or suitcases of concentration camp victims.

As Alison Landsberg also argues, films like director Paul Verhoeven's Total Recall predict a future where there will be memory implants. The main character, Quade, receives someone's memory, thus ending up on Mars, where he deposes Cohagen, the tyrant, who controls the population by limiting the distribution of oxygen. Another film that tackles the subject is the Blade Runner series, where replicants are given a false memory to control them and give them the impression of normality [15].

Both films examine the ethics and implications of implanted memory. If memory can be transplanted, what differentiates one person from another? And how will this affect museums and memory? Will experiencing a memorial or museum be done from a distance and become just a transfer of experience?

5. Conclusions

The psychological dimensions of memory play a crucial role in how memorials are perceived and experienced. Research indicates that collective memory can evoke powerful emotional responses that can either facilitate healing or perpetuate divisions within societies. As such, future memorials must consider the affective dimensions of memory, aiming to create spaces that promote reflection, dialogue and reconciliation, rather than simply commemorating past grievances.

The role of mass media in shaping prosthetic memories is particularly significant. For example, films like Hotel Rwanda serve as vehicles for viewers to engage with the Rwandan genocide, allowing them to experience a form of memory that is not their own but is nonetheless deeply felt [16].

In conclusion, the future of memorials is likely to be characterized by a greater focus on collective memory, technological integration, and the psychological impact of remembrance. As societies continue to grapple with their histories, memorials will play a vital role in shaping collective identities and fostering a sense of belonging within diverse communities. The challenge is to ensure that these memorials are inclusive, reflective of multiple narratives and able to evolve with societal change.

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Viitorul memoriei

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Abstract
Obiective: Viitorul memorialelor este un subiect complex și în evoluție, care reflectă schimbarea valorilor societății, progresele tehnologice și schimbările culturale. Pe măsură ce practicile tradiționale de comemorare sunt în declin, apar noi abordări care răspund nevoilor și preferințelor contemporane. Această transformare este evidentă în diferite sectoare, inclusiv în industria funerară, a cimitirului și a incinerației, care se adaptează pentru a răspunde cerințelor unei societăți mai diverse și mai mobile. Studiul are ca obiectiv înțelegerea modului în care memorialele viitorului o să arate. Cercetarea se bazează pe studiul doctoral în desfășurarea de la Școala doctorală de arhitectură din cadrul UAUIM, *Memorii divergente- Monumentele nimănui*, început în 2020 și pe articole apărute în diverse publicații, precum revista Arhitectura 4-5 2023(706-707), unde a apărut un articol despre situația monumentelor comuniste din Ucraina. Abordarea lucrării s-a făcut prin analizarea studiilor de caz recente, precum și a monumentelor trecute, pentru a înțelege schimbările majore prin care trece societatea astăzi. Asupra memorialelor au fost făcute observații atente, fiind luat în calcul, felul în care oamenii astăzi păstrează memoria cuiva în mediul virtual, cât și în mediul fizic.Studiul prezintă un interes pentru studenți, profesori cât și pentru cercetători, pentru a înțelege viitorul memorialelor. Pentru arhitecți, studiul reprezintă un punct de reper, care poate să-i ghideze în proiectarea monumentelor adecvate secolului al XXI-lea. Cercetările indică faptul că există o schimbare semnificativă către practicile de comemorare personalizate și informale, care sunt din ce în ce mai favorizate de cei îndoliați față de ceremoniile formale tradiționale. Această tendință evidențiază o dorință tot mai mare pentru memoriale care rezonează la nivel personal, permițând indivizilor să-și exprime durerea și amintirea în moduri care să se simtă autentice pentru ei. Lucrarea pune problema memorialelor viitorului și felul în care o să arate în viitor. Temă a rămas încă neexplorată și reprezintă o oportunitate important de a se înțelege perspectivele monumentelor în cadrul epocii moderne.

Cuvinte cheie: Virtual, Internetul în cadrul memoriei, Digital.

1. Introducere
Viitorul memorialelor este un subiect complex și în evoluție, care reflectă schimbarea valorilor societății, progresele tehnologice și schimbările culturale. Pe măsură ce practicile tradiționale de comemorare sunt în declin, apar noi abordări care răspund nevoilor și preferințelor contemporane. Această transformare este evidentă în diferite sectoare, inclusiv în industria funerară, a cimitirului și a incinerației, care se adaptează pentru a răspunde cerințelor unei societăți mai diverse și mai mobile. Cercetările indică faptul că există o schimbare semnificativă către practicile de comemorare personalizate și informale, care sunt din ce în ce mai favorizate de cei îndoliați față de ceremoniile formale tradiționale. Această tendință evidențiază o dorință tot mai mare pentru memoriale care rezonează la nivel personal, permițând indivizilor să-și exprime durerea și amintirea în moduri care să se simtă autentice pentru ei.

1.1. Ce sunt monumentele?
Monumentele și memorialele sunt o parte intregrantă din spațiul urban. Acestea iau forme variate precum: memoriale de război, statui publice, clădiri monumentale, piețe, temple, grădini memoriale, piramide, cenotafuri, obeliscuri, cercuri de piatră, incinte civice și chiar părți din oraș [1].
Cuvântul ”monument” își are originea în termenul latinesc ”monumentum”. În mitologia greacă, ”Mnemosyne” este una dintre titanide, fiica lui Gaia și Uranus [2]. ”Mnemosyne”

este zeița memoriei și stă la originea cuvântului grecesc ”mnemonic”. Termenul desemnează un ajutor sau reper al memoriei.

Termenul de memorial este folosit cu precădere pentru forme construite care comemorează persoane decedate ca urmare ca unor catastrofe sau războaie. Monumentele și memorialele, pe lângă scopul comemorativ au și semnificații politice, legitimând pe cei care le-au construit. Acestea pot prezenta o narațiune atent aleasă care se focusează pe evenimente sau indivizi, după ideologia sau dorința elitelor politice. Astfel, memoria culturală este sub forma unui discurs, modelat după intențiile politice.

Adolf Loos scria că singura parte din arhitectură care devine artă este arhitectura memorială, mai precis mormântul și monumentul. Potrivit lui, această parte din arhitectură nu are o funcțiune practică [3].

Monumentele au următorul caracter:

- Joacă un rol important în definirea memoriei și identității naționale;
- Monumentele pot să aibă interpretări multiple;
- Monumentele legitimează pe cei care dețin puterea;

2. Tendințele actuale

Una dintre cele mai semnificative tendințe care modelează viitorul monumentelor este integrarea tehnologiilor digitale în conservarea și interpretarea acestora. Evoluția metodologiilor de reconstrucție digitală, în special în contextul realității virtuale (VR) și al realității augmentate (AR), permite experiențe captivante care pot spori implicarea publicului cu siturile istorice [4]. Aceste tehnologii sunt deosebit de valoroase pentru site-urile care sunt dificil de accesat, fie din cauza constrângerilor geografice, fie din cauza limitărilor fizice ale vizitatorilor. Oferind experiențe interactive, aceste instrumente digitale pot lărgi audiența pentru moștenirea culturală și pot stimula interesul pentru eforturile de conservare.

Mai mult, proiectarea spațiilor memoriale trece printr-o transformare, îndepărtându-se de la monumentele statice tradiționale către peisaje comemorative mai dinamice și interactive. Această schimbare reflectă o dorință în creștere pentru spații care facilitează interacțiunea utilizatorului prin experiențe senzoriale, cum ar fi atingerea și participarea la acțiuni comemorative [5]. Evoluția designului memorial subliniază importanța creării de medii care rezonează cu publicul contemporan, favorizând o conexiune mai profundă cu narațiunile pe care le reprezintă.

În plus, comercializarea patrimoniului cultural prezintă atât provocări, cât și oportunități pentru viitorul monumentelor. Pe măsură ce patrimoniul devine din ce în ce mai comercializabil, există riscul de a-i dilua semnificația în favoarea intereselor comerciale. Cu toate acestea, această tendință deschide, de asemenea, căi pentru finanțare și sprijin pentru eforturile de conservare, cu condiția ca considerentele etice să fie prioritizate [6].
Echilibrul dintre comercializare și reprezentarea autentică a patrimoniului cultural va fi crucial în modelarea viitorului peisaj al monumentelor.

Viitorul monumentelor se bazează din ce în ce mai mult pe colaborarea interdisciplinară dintre istorici, arheologi, artiști și tehnologi. Această abordare de colaborare nu numai că îmbogățește înțelegerea și reprezentarea moștenirii culturale, dar promovează și soluții inovatoare pentru conservarea și interpretarea monumentelor. Pe măsură ce complexitățile managementului patrimoniului cultural evoluează, integrarea diverselor perspective și expertiză devine esențială pentru crearea de monumente care rezonează cu publicul contemporan, în timp ce onorează narațiunile istorice. Unul dintre beneficiile principale ale colaborării interdisciplinare este îmbunătățirea documentării și analizei prin tehnologii moderne.

De exemplu, imaginile de înaltă rezoluție obținute prin fotogrametrie și scanare laser au revoluționat modul în care moștenirea culturală este înregistrată și analizată [7]. Aceste tehnologii facilitează documentarea detaliată a caracteristicilor complexe ale artefactelor și elementelor arhitecturale, permițând istoricilor și arheologilor să efectueze studii mai cuprinzătoare. Eforturile de colaborare ale tehnologilor, care oferă instrumentele necesare, și ale istoricilor și arheologilor, care oferă perspective contextuale, creează un cadru robust pentru înțelegerea semnificației monumentelor în contextele lor istorice și culturale.

Mai mult, rolul artiștilor în acest dialog interdisciplinar nu poate fi exagerat. Artiștii servesc ca muze a inovației, inspirând noi moduri de a gândi și de a se implica în moștenirea culturală [8]. Perspectivele lor creative pot duce la dezvoltarea de noi narațiuni și interpretări care rezonează cu publicul modern. De exemplu, integrarea practicilor artistice cu metodologiile științifice poate genera forme hibride de cunoaștere care provoacă granițele tradiționale și favorizează conexiuni mai profunde între public și monumentele pe care le întâlnesc [9]. Această sinergie nu numai că îmbunătățește experiența estetică a monumentelor, dar încurajează și implicarea critică cu poveștile pe care le spun. Potențialul de colaborare interdisciplinară se extinde dincolo de documentare și interpretare artistică; include, de asemenea, dezvoltarea de noi tehnologii care pot fi aplicate pentru conservarea monumentelor.

Colaborarea dintre artiști și tehnologi poate duce la crearea de lucrări de artă dependente de software care utilizează tehnologie de ultimă oră pentru a implica publicul în moduri noi [10]. Astfel de proiecte pot servi drept platforme pentru interacțiunea publică, permițând comunităților să participe la dialogul continuu în jurul moștenirii lor culturale. Această abordare participativă nu numai că democratizează narațiunea din jurul monumentelor, dar stimulează și un sentiment de proprietate și responsabilitate în rândul membrilor comunității. În plus, integrarea diverselor discipline poate aborda dimensiunile etice și sociale ale creării și conservării monumentelor.

Pe măsură ce discuțiile despre reprezentarea istoriilor marginalizate câștigă proeminență, echipele interdisciplinare pot lucra împreună pentru a se asigura că monumentele reflectă o narațiune mai incluzivă [11]. Reunind istorici, arheologi, artiști și tehnologi, aceste echipe pot explora în colaborare complexitățile identității și memoriei, creând monumente care onorează diverse perspective și experiențe. În concluzie, pledând pentru colaborarea interdisciplinară între istorici, arheologi, artiști și tehnologi este crucială pentru modelarea viitorului monumentelor. Această abordare de colaborare nu numai că îmbunătățește

documentarea și interpretarea moștenirii culturale, dar promovează și soluții inovatoare care rezonează cu publicul contemporan. Îmbrățișând perspective și expertiză diverse, putem crea monumente care nu doar comemorează trecutul, ci și implică și inspiră generațiile viitoare.

3. Studii de caz

Utilizarea tehnicilor de modelare și proiecție 3D oferă o oportunitate unică de a interacționa cu aceste figuri istorice într-o manieră care transcende metodele tradiționale de conservare. Buddha Bamiyan, care au fost distruși în 2001, au devenit un punct focal pentru discuțiile despre modul în care tehnologiile avansate pot fi folosite pentru a recrea și vizualiza artefacte culturale pierdute [12]. Utilizarea tehnicilor de modelare și proiecție 3D oferă o oportunitate unică de a interacționa cu aceste figuri istorice într-o manieră care transcende metodele tradiționale de conservare.

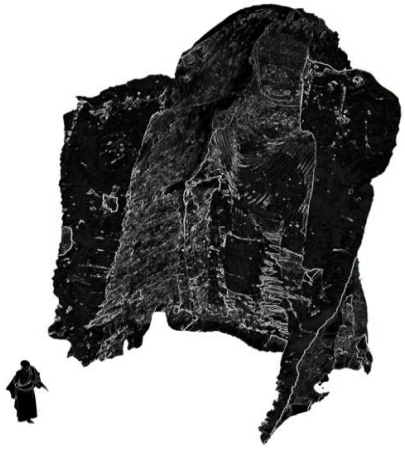

Fig. 7. Statuia Buddha Bamiyan, Afganistan
Sursa:Desen Bogdan Oțelea

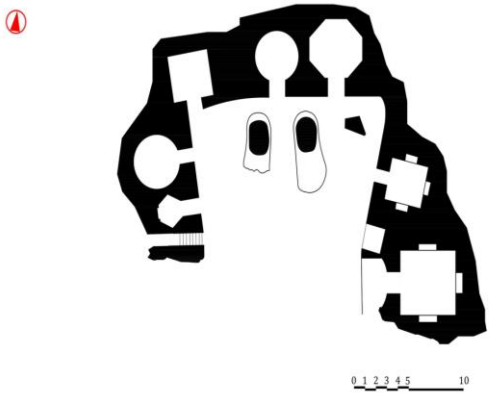

Fig. 8. Planul statuii Buddha Bamiyan
Sursa:Desen Bogdan Oțelea

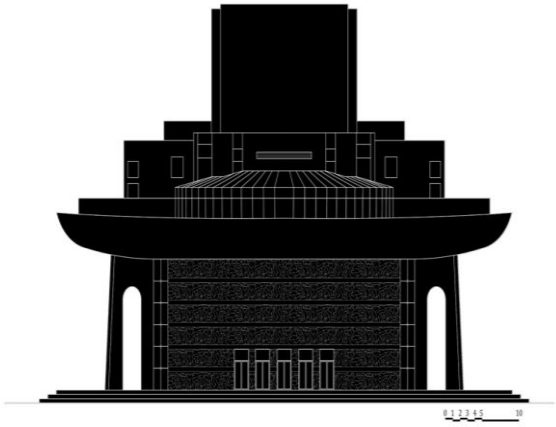

Fig. 9. Fațada Teatrului Național București, pe care era prevăzută o frescă monumentală cu istoria țării. Fresca poate fi proiectată pe fațadă fără să fie nevoia pictării sale
Sursa:Desen Bogdan Oțelea

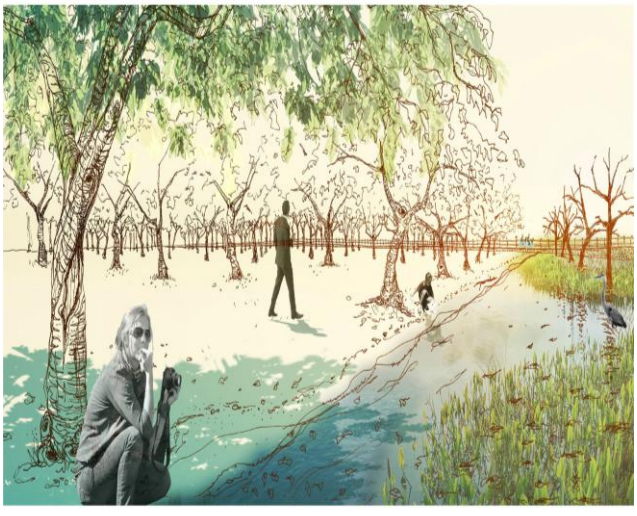

Fig. 10. Climate Chronograph
Sursa: https://terrene.co/designs/climate-chronograph

Climate Chronograph, din cadrul concursului de memoriale ale viitorului, conferă o nouă viziune asupra memorializării. Format dintr-o platformă de observație și o grădină, ambele la nivelul mării, memorialul își propune să marcheze efectele încălzirii globale asupra lumii. Odată cu topirea ghețarilor, nivelul mării va crește și va inunda lent grădina. Astfel, procesul va fi înregistrat în timp real și memorialul va deveni și un observator al încălzirii globale [13].

Comparativ cu un memorial contemporan, o astfel de abordare înseamnă o folosire a unor materiale perisabile care poate suferi modificări în funcție de contexte viitoare. Un astfel de monument o să prezinte imagini diferite de-a lungul vieții sale.

Studio Drift, un duo de artiști olandezi propun refacerea unor monumente incomplete, folosind drone iluminate. Scopul lor este de a ajuta arhitecții să vizualizez designul la scară reală, fără să fie nevoie de structuri sau construcții temporare. Astfel de instalații la scară mare, folosind drone, pot recrea contextul distrus al unor monumente sau memoriale [14].

Fig. 11. Folosirea dronelor pentru reconstituirea unui monument
Sursa: https://www.domusweb.it/en/sustainable-cities/gallery/2022/11/03/studio-drifts-drones-illuminate-unfinished-monuments.html

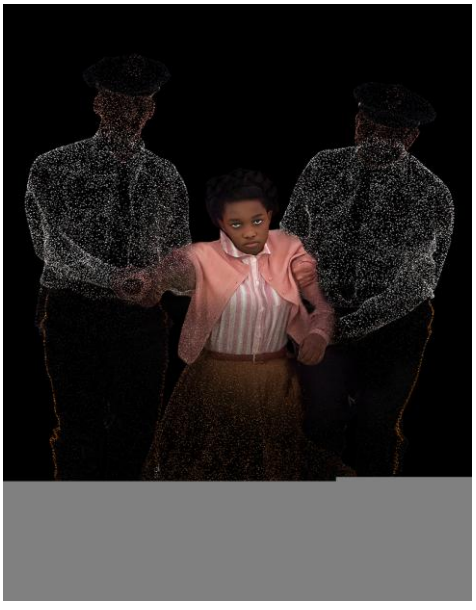

Fig. 12. Arestarea lui Claudette Colvin, surprinsă într-o instalație la centrul Pompidou. Claudette Colvin a fost arestată în 1950, în Montgomery, în statul Louisiana, pentru refuzul de a ceda un loc în autobuz pentru o persoană albă
Sursa: https://www.centrepompidou.fr/fr/magazine/article/noire-grace-a-la-realite-augmentee-une-plongee-dans-lamerique-segregationniste

4. Monumentele viitoare

Odată cu evoluția societății moderne, unde o mare parte din populație utilizează calculatorul și internetul, comemorarea s-a mutat din lumea fizică în cea virtuală. Internetul oferă niște posibilități vaste de încărcare a imaginilor și cântecelor care dă mediului virtual un caracter dinamic și expresiv. Folosirea limbajului culturii pop și cel colocvial dă un caracter vernacular.

Memorialele virtuale facilitează interacțiunea dintre persoane și devine un spațiu terapeutic prin oportunitatea de acțiune și exprimare. Astfel, site-urile de caritate oferă ajutor pentru anumite cauze, persoanelor sau familiilor celor afectați, în timp ce comemorează un anumit eveniment.

Un avantaj major al acestor memoriale este reprezentat de răspândirea largă a mesajului care poate ajunge în orice punct al lumii. Faptul că nu este construit fizic ajută la adaptarea sa contextul prezent.

Memoria de astăzi a ajuns într-un stagiu în care populația lumii împărtășește o conștiință comună. Diferite evenimente din lume devin preocuparea tututor, într-un efort de centralizare. Mass-media, cultura și în special filmele ne influențează percepția asupra limitelor culturale. Filme precum Lista lui Schindler a transformat Holocaustul într-o tragedie cunoscută și asumată de oameni din țări ale lumii, care n-au avut vreo legătura cu evenimentele.

Din perspectiva autoarei Alison Landsberg, conceptul de memorie prostetică n-are o bază reală, dar funcționează ca o memorie autentică, în cultura americană. Procesul de memorie a apărut ca urmare a necesității integrării în societatea americană, a imigranților care n-aveau o origine legată de țara adoptivă. Migrația în lumea nouă s-a suprapus peste apariția noilor tehnologii, precum cinematograful.

Cele mai de impact piese ale unui muzeu rămân artefactele autentice care au puterea de a rupe dihotomia dintre muzeu și individ. Astfel de artefacte sunt prezente în muzeele din lume, precum vagoanele de transport sau valizele victimelor din lagărele de concentrare.
Cum susține și Alison Landsberg, filme precum Total Recall al regizorului Paul Verhoeven, prevăd un viitor unde vor exista implanturi de memorie. Personajul principal, Quade, primește memoria cuiva, astfel ajungând pe Marte, unde îl detronează pe Cohagen, tiranul, care controlează populația, prin limitarea distribuției de oxigen. Alt film care abordează subiectul este seria Blade Runner, în care replicanții primesc o memorie falsă, prin care să-i controleze și să le dea impresia de normalitate [15].

Ambele filme examinează etica și implicațiile memoriei implantate. Dacă memoria se poate transplanta, cu ce se diferențiază o persoană de alta? Și acest lucru cum va influența muzeele și memoria? Experimentarea unui memorial sau muzeu se va face de la distanță și va deveni doar un transfer al experienței?

5. Concluzii

Dimensiunile psihologice ale memoriei joacă un rol crucial în modul în care memorialele sunt percepute și experimentate. Cercetările indică faptul că memoria colectivă poate evoca răspunsuri emoționale puternice, care fie pot facilita vindecarea, fie pot perpetua diviziunile în cadrul societăților. Ca atare, viitoarele memoriale trebuie să ia în considerare dimensiunile afective ale memoriei, urmărind să creeze spații care să promoveze reflecția, dialogul și reconcilierea, mai degrabă decât simpla comemorare a nemulțumirilor din trecut.

Rolul mass-media în modelarea amintirilor protetice este deosebit de semnificativ. De exemplu, filme precum Hotel Rwanda servesc ca vehicule pentru ca spectatorii să se implice în genocidul din Rwanda, permițându-le să experimenteze o formă de memorie care nu este a lor, dar este totuși profund simțită [16]. În concluzie, viitorul memorialelor este probabil caracterizat de un accent mai mare pe memoria colectivă, integrarea tehnologică și impactul psihologic al amintirii. Pe măsură ce societățile continuă să se confrunte cu istoriile lor, memorialele vor juca un rol vital în modelarea identităților colective și în stimularea sentimentului de apartenență în cadrul diverselor comunități. Provocarea constă în a ne asigura că aceste memoriale sunt incluzive, reflectă mai multe narațiuni și capabile să evolueze odată cu schimbările societale.

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The impact of the digital economy on China's economic development

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Abstract
This paper explores the impact of the digital economy on China's economic growth through three phases: the initial phase (1994-2002), rapid growth (2003-2012), and maturity (2013-present). It emphasizes the digital economy's significant role in increasing China's GDP, bolstering foreign trade, and enhancing global competitiveness. Key developments include the establishment of major internet companies, the swift rise of e-commerce, and widespread digital transformation across industries. Using a case study approach, the analysis draws on data from the National Bureau of Statistics and industry reports, outlining how the digital economy has been instrumental in driving economic growth and transforming industries. However, the study also identifies considerable regional disparities and challenges in digital transformation, particularly among small and medium enterprises (SMEs), which face high digitalization costs and limited resources. These findings have implications for policymakers, industry leaders, and researchers, offering insights into how digital investment and innovation can support sustainable growth and bridge economic divides across regions and sectors. This paper underlines the strategic importance of targeted investment in digital infrastructure and core technologies as essential drivers for China's economic resilience and long-term competitiveness on a global scale, thereby illustrating the vital role of the digital economy in modernizing the national economy and positioning China at the forefront of digital transformation.

Keywords: economic transformation, regional disparities, digital infrastructure, sustainable growth, competitiveness.

1. Introduction
The digital economy has become a transformative force in modern economic development, reshaping industries, enhancing productivity, and driving new avenues for growth. In China, this digital transformation has been particularly significant, accompanying rapid economic expansion and structural shifts over the past few decades. As one of the world's largest and most dynamic economies, China offers a unique lens to examine how digitalization influences various aspects of economic performance, including gross domestic product (GDP), international trade, and industrial competitiveness. Since China's initial connection to the global internet in the early 1990s, the digital economy has evolved through distinct phases—starting with foundational digital infrastructure, progressing to an era of accelerated growth marked by e-commerce and mobile internet, and maturing into a sophisticated, data-driven economy. This evolution has supported China's economic ambitions, not only by contributing to overall GDP growth but also by modernizing traditional industries and fostering innovation in areas such as artificial intelligence, e-commerce, and digital finance. Despite these advancements, the digital economy's development in China has been uneven, with significant disparities across regions and sectors. While major urban centers have flourished as digital hubs, many rural and less developed areas struggle to keep pace, exacerbating regional economic divides. Moreover, small and medium enterprises (SMEs) often face challenges in adopting digital solutions due to high costs and resource constraints. Addressing these gaps is essential for ensuring

that the benefits of the digital economy are distributed equitably across China's diverse economic landscape.

This paper seeks to analyze the impact of the digital economy on China's economic development by examining key trends, challenges, and opportunities within this domain. Through an exploration of the digital economy's historical phases and its role in driving economic growth and innovation, this study aims to provide insights into how digital transformation can support sustainable development and contribute to China's long-term global competitiveness. The findings offer valuable implications for policymakers, industry leaders, and scholars interested in understanding the strategic importance of digital infrastructure and innovation in advancing economic resilience and modernization in a globalized era.

2. Literature review

The rapid development of the digital economy has significantly impacted economic growth patterns globally, particularly in emerging economies like China. Research indicates that digital economy advancements drive economic growth through technological progress and innovation, making it a vital source of productivity enhancement [1]. The definition and evaluation framework of the digital economy have been widely discussed; for instance, Bukht and Heeks proposed a foundational concept of the digital economy that aids in analyzing its influence on various economic indicators [2]. Focusing on China, Chen and Ding demonstrated that the digital economy plays a crucial role in fostering regional innovation and economic growth by enhancing resource allocation efficiency and promoting innovation [3]. Globally, the widespread use of the internet has fostered international trade [4]. Goldfarb and Tucker analyzed the transformative effects of digital technologies on traditional economic models, a transformation particularly prominent in China [5]. Guo, Feng, and Li found that digital transformation has improved firm performance across China's regions, positively impacting national economic growth [6]. Digital finance, a subset of the digital economy, has also shown substantial effects on economic growth [7]. Furthermore, the digital economy has been integral to total factor productivity growth, particularly in Chinese industries [8]. In the area of e-commerce, research indicates positive impacts on economic growth, especially in emerging economies [9]. A report by McKinsey Global Institute emphasized that digitalization enhances China's global competitiveness, particularly in high-tech and innovation sectors [10].

However, regional imbalances accompany the development of the digital economy. Qu and Yu identified significant disparities in digitalization progress among Chinese regions, providing insights into the uneven pace of digital transformation in China [11]. Additionally, the digital economy has boosted small business innovation and entrepreneurship, injecting new vitality into economic growth [12]. Digital technologies have also contributed to green development; Wang and Zhang highlighted the role of the digital economy in promoting sustainable growth in line with China's sustainability goals [13].

Overall, the digital economy has substantially enhanced competitiveness in traditional sectors, especially manufacturing. Zhao, Zhang, and Huang illustrated that China's

manufacturing sector has gained increased competitiveness and innovation through digitalization, facilitating industrial upgrades and supporting high-quality economic development [14].

3. The evolution of China's digital economy

3.1. Initial stage: 1994-2002

After China officially connected to the international internet in 1994, the number of internet users grew rapidly, and internet companies such as Tencent (1998), Alibaba (1999), and Baidu (2000) were established and developed rapidly. During this initial stage, China's digital economy and services remained relatively basic, primarily encompassing news, search engines, and internet communications. At the same time, to compete for traffic and accumulate customers, most companies based their business models on successful foreign examples, engaging in some degree of imitation innovation while neglecting the importance of independent innovation. This was the trigger for the bursting of the global Internet economic bubble in 2000, which also affected China's domestic Internet industry and led to a temporary downturn in the development of China's digital economy.

3.2. Rapid growth period: 2003-2012

The SARS epidemic in 2003 accelerated the rapid growth of e-commerce, especially online retail. This allowed China's digital economy to recover from the 2–3-year downturn in the initial stage and enter a phase of rapid expansion. In 2003, the birth of "Taobao" and Alipay pushed eBay out of the Chinese market and gradually developed into leading platforms in the fields of e-commerce and third-party payment. During the period from 2006 to 2012, China's online retail sales growth rate remained above 50%, successively breaking through the 100 billion and 1 trillion thresholds. Among them, e-commerce was recognized as a strategic emerging industry in China. During this period, the continuous emergence of new formats such as "blogs (2005)" and "Weibo (2009)" enabled netizens to deeply participate on the internet as individuals, thus having an incomparable profound impact on the social economy. Additionally, the growth rate of Chinese internet users began to slow, entering a phase of steady development, making it difficult for companies to profit from the previously rapid increase in internet users. According to relevant data, the number of Chinese internet users reached 564 million in 2012, with a growth rate of 9.92%. Among them, the number of mobile internet users was 420 million, growing at a rate of 18.1%, much higher than the overall internet user growth. This was largely due to the widespread adoption of smart devices and wireless network upgrades, signaling that China's digital economy is poised to enter a new phase of development.

3.3. Maturity period: 2013-present

As the number of mobile internet users increased, the internet industry entered the mobile era, and the development pattern of China's digital economy stabilized, entering a mature phase. During this period, the advancement and maturation of information and internet technologies drove the digitalization and intelligent growth of the information economy and internet economy. At this stage, the digital economy formed two major structures: one is industrial digitalization represented by ride-hailing, food delivery, and housekeeping services. Traditional industries are transitioning online based on internet retail, making digitalization a necessary transformation direction for these industries; the other is format

innovation represented by the sharing economy and online live streaming, continuously injecting new vitality and momentum into China's digital economy. Currently, the digital economy has become a crucial driving force for China's economic transformation, structural optimization, and quality efficiency improvement.

3.4. The current state of China's digital economy

At present, due to the ongoing iterative advancements in information technology, the digital economy is experiencing unprecedented growth in speed, breadth, and influence. It has emerged as a pivotal force propelling the swift progression of the global economy and society. This transformation is reorganizing global market resources, altering the structure of the global economic scale, and modifying the competitive dynamics worldwide. From the 18th to the 20th century, three major industrial revolutions took place, bringing earth-shaking changes to the world. Mechanization, electrification, and then informatization, each wave of disruptive technological innovation brought a great improvement in social productivity, a leap in human quality of life, and a great development in human history. China has positioned itself at the forefront of the information industrial revolution. As of 2023, China has built the world's largest and most advanced network infrastructure, with a total of 3.38 million 5G base stations, achieving the world's first deployment based on standalone networking mode. 5G innovative applications cover many areas of life, including transportation, healthcare, culture and tourism, and education.

4. The impact of the digital economy on China's GDP

The total economic volume represents the total wealth of society and is an important indicator for assessing economic growth. It reflects China's economic expansion in scale and speed. According to the National Bureau of Statistics of China and common research practice, gross domestic product (GDP) is commonly used to measure the total economic volume. Therefore, this analysis continues existing research by using constant price GDP to explain the total economic volume.

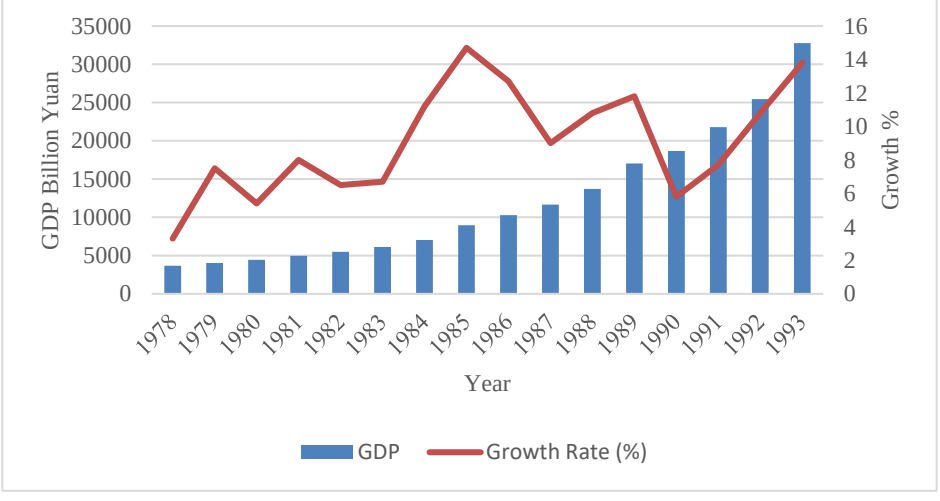

Fig.01. 1978-1993 China GDP and Growth Rate
Source: Own compilation based on data from the National Bureau of Statistics of China

The chart above shows the development of China's gross domestic product (GDP) and its growth rate in the era before the digitalization of the economy. From 1978 to 1993, although GDP was relatively low, it showed a steady upward trend and was able to increase the economic volume almost tenfold during this period. This growth was mainly due to the stable political situation since the founding of the People's Republic of China and the benefits of the reform and opening-up policy. China regained its rightful position in international organizations such as the International Monetary Fund and the World Bank, established strong diplomatic relations worldwide and vigorously developed key traditional national infrastructures such as satellite communications, highways and nuclear power plants. The country gradually expanded its opening-up from the coastal, river and border areas to the interior and provincial capitals, forming an advanced opening-up pattern centered on economic and technological development zones and open areas, leading to robust economic growth. The GDP growth rate during this period showed significant fluctuations and lacked stability. The sharp decline in economic growth from 1989 to 1990 was primarily influenced by global shifts in the political and economic systems of socialist countries and domestic political unrest in China. Despite this, China's economy remained on a rapid growth trajectory, with an average growth rate close to 10%, which was often referred to as the "China Miracle."

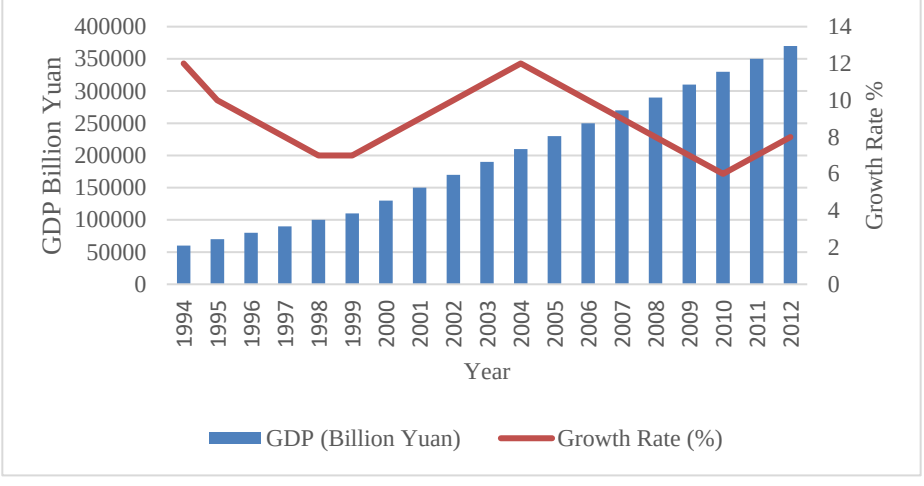

Fig. 2. 1994-2012 China GDP and Growth Rate
Source: Own compilation based on data from the National Bureau of Statistics of China

The second stage represents the rapid progress of digital technology, with technological progress increasingly flowing into production and daily life, heralding the development phase of the digital economy. The chart above shows the changes in China’s GDP and its growth rate during this period. Over the past 20 years, China’s GDP has grown significantly, increased tenfold and is on a steady upward trend. The 2008 global financial crisis did not significantly impact China’s GDP due to the timely increase in infrastructure investment of 4 trillion yuan, ensuring continuous and stable growth. This stage continued the high-speed economic growth of the first stage, with an average growth rate reaching 10%, though there was still some instability. In 2008, the GDP growth rate experienced a

sharp decline due to the global financial crisis. Although China's 4 trillion-yuan infrastructure investment ensured economic development did not stall, the GDP growth rate was still considerably impacted.

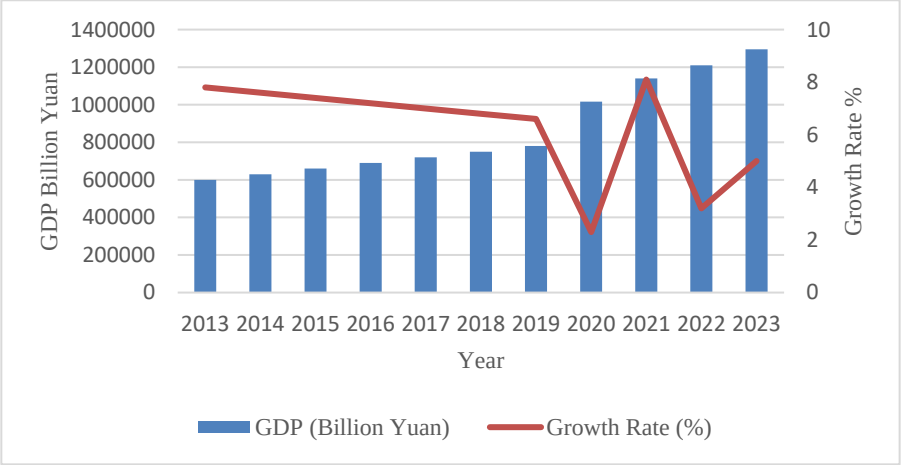

Fig. 3. 2013-2023 China GDP and Growth Rate
Source: own compilation based on data from the National Bureau of Statistics of China

Since the "Big Data Year" began, data across society has grown explosively, profoundly transforming the production and lifestyle of the economic society, and the digital economy has entered a period of prosperity. The above chart shows the changes in GDP and its growth rate during this stage. In the third stage, GDP steadily increased, remaining above 50 trillion yuan and approaching the 100 trillion-yuan mark. The total economic volume rose to the second in the world, and in just six years, the economic volume is about to double. The GDP growth rate has noticeably decreased, but growth stability has improved, maintaining a growth rate of around 7%. This marks a shift from the previous period's average high-speed growth of approximately 10%, entering a new normal in economic development.

Comparing the three phases, the first stage was characterized by a low GDP and a low stability of the GDP growth rate. In the second stage, GDP growth was considerable, the growth rate was higher, and stability improved considerably compared to the first stage. In the third stage, the GDP growth cycle shortened, the growth rate declined, but stability remained high. Overall, GDP continued to rise in all three phases, with the growth rate declining and tending to stabilize amid fluctuations. It is clear that the growth of the digital economy has had a sustained, positive impact on the GDP growth rate. This underscores the strong support and driving role of China's digital economic development in promoting economic growth and highlights the importance of continuing to vigorously develop the digital economy through various channels to further strengthen its economic driving role.

5. The impact of the digital economy on China's international trade

The rapid progress of the global digital economy has led to a rapid increase in cross-border e-commerce. Data from the China National E-commerce Research Center shows that

China's cross-border e-commerce transactions reached 15.7 trillion yuan, an increase of 10.56% from 14.2 trillion yuan in 2021. As shown in the table, the scale of cross-border e-commerce in China grew from 9 trillion yuan in 2018 to 15.7 trillion yuan in 2022, showing rapid development in the past five years. Between 2018 and 2020, China was in the early stage, but cross-border e-commerce grew rapidly. In 2021, overall growth remained stable despite the challenges posed by the COVID-19 pandemic and the stabilization of the digital transaction environment.

In recent years, the cross-border e-commerce sector has seen significant growth, with various regions nationwide accelerating the establishment of comprehensive pilot zones and digital havens. In addition, many prominent cross-border e-commerce platforms such as Alibaba, AliExpress, DHgate and Yuguo have emerged, driving the robust growth of digital commerce in China.

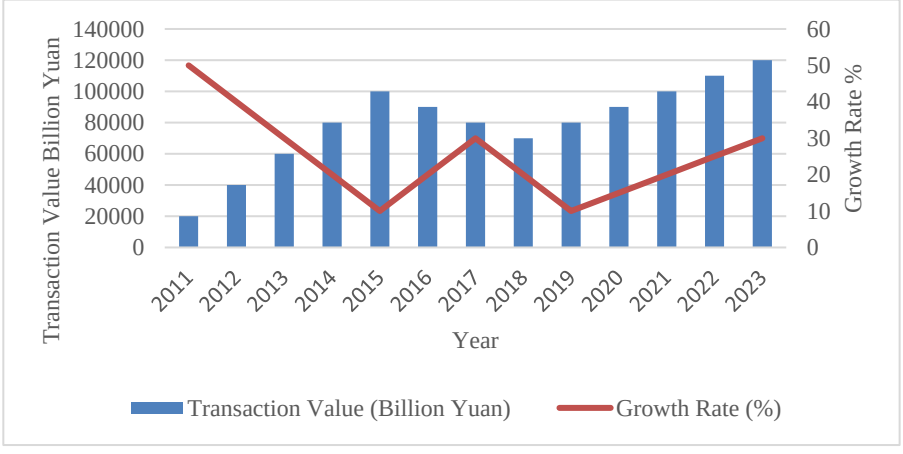

Fig. 4. 2011-2013 China's Cross-border E-commerce Transaction Volume and Growth Rate
Source: own compilation based on data from the E-commerce Research Center and China Daily

For example, as of 2022, Alibaba's cross-border e-commerce business has expanded to over 200 countries, with more than 100 million users, including International Station, 1688 Overseas Station, and Taobao Global, and over five million overseas buyers. With the optimization of cross-border e-commerce policies and logistics, and the increase in consumer demands for shopping experiences, Alibaba launched the "Digital Going Global 4.0 Plan" and released the Brand Going Global Methodology in 2022. The company plans to use its full platform resources to support competitive B2B e-commerce enterprises by providing customized brand solutions, aiming to cultivate 100 benchmark B2B cross-border e-commerce brands between 2022 and 2023.

6. The international competitiveness of Chinese digital products has significantly increased

The range of China's digital products is becoming increasingly diverse, and their international competitiveness is also strengthening. For example, in the gaming industry, South Korean and American games once dominated the Chinese market, but now Chinese

games have entered the global stage. In 2022, the total market value of the global gaming market was 1.1107 trillion yuan, down 6.96% from the same period last year. The overseas revenue of Chinese online games mainly comes from the United States, Japan, South Korea, and Germany, with the United States accounting for 32.31%, Japan 17.12%, and South Korea 6.97%. According to App Magic's statistics, "Honor of Kings," "PUBG Mobile," and "Genshin Impact" rank among the top three in global revenue, with overseas revenues of 2.224 billion USD, 1.725 billion USD, and 1.562 billion USD, respectively.

Furthermore, Chinese social media and short video applications have made remarkable achievements in the international market.In 2022, the overseas versions of apps like WeChat and Douyin ranked among the top in global downloads, with their influence steadily increasing.TikTok, the international version of Douyin, is now available in 75 different languages and is used in more than 150 countries around the world.At the same time, international versions of apps like "Douyin" and "Kuaishou" have been widely accepted and loved by users in countries like Japan, the United States, Indonesia, and Thailand.

China has also made significant contributions in the field of digital media. In 2021, the international export value of Chinese TV dramas reached 56.83 million USD, an increase of 118% year-on-year. In order to meet the needs of foreign readers for digital reading, Zhangyue Technology developed a multilingual service platform called "iReader," which currently has users in more than 40 countries and regions, with a total of over 50 million visits.

7. Problems in China's digital economy

The digital transformation of enterprises within regions varies greatly.

As the main force of China's economic development, the manufacturing industry must undergo digital transformation to better survive in a competitive market. However, digital transformation requires a substantial investment in digital infrastructure, changes in traditional business and organizational models, and the addition of digital talent after the transformation. This makes digital transformation risky for enterprises and increases the difficulty of transformation. As a result, many small and medium-sized enterprises (SMEs) in China face difficulties in digital transformation due to the high costs and lack of motivation. On the other hand, some large enterprises with transformation advantages invest significantly in digital technology and accelerate their layout to seize development opportunities and strategic positions. This widens the technology investment gap among manufacturing enterprises in China, leading to inconsistent digital transformation progress among large, medium, and small enterprises. Additionally, most of these large manufacturing enterprises are still in the initial stages of transformation, with integration and convergence of digital transformation needing improvement. They have not yet formed leading enterprises that exemplify "smart manufacturing + industrial internet," making it difficult to lead digital transformation and support high-quality development of the provincial digital economy. Meanwhile, as a manufacturing powerhouse, China's high-tech industry value-added rate is only about 20%, far below the international level of 40%. Although China's "14th Five-Year Plan" clearly proposes promoting the clustered

development of the digital industry, encouraging SMEs to actively integrate into digital platforms to create a digital enterprise community for coordinated development and mutual benefit along the supply chain. However, currently, both the digital industrialization foundation and the industrial digital transformation in China are in the initial stages, making it difficult to form high-level digital industry clusters.

8. Summary

The digital economy is having a significant impact on the development of economic growth. Data, as a new factor of production, is crucial to the transition between new and old growth engines in China's economic development. New formats and scenarios centered around data elements will sustainably support China's high-quality economic growth. In the digital economy, social production and life will be digitized, networked and intelligent, with new digital infrastructure enabling extensive integration across various industries. The construction of new digital infrastructure facilitates the use of digital and information technology to solve factor mobility problems and consolidate data as a factor of production. It supports the emergence of new economic formats and transforms traditional human-machine production models. During the 2020 pandemic, innovative technologies such as big data and artificial intelligence accelerated the launch of many new online industries, highlighting the resilience of the Chinese economy in the midst of the pandemic. Therefore, it is obvious that the development of new digital infrastructures creates effective demand, stimulates investment and ensures that the economy achieves steady quality growth while maintaining reasonable volume growth through practical application scenarios.

China's digital trade sector has experienced rapid growth. Nevertheless, there are significant balance issues in the development of digital trade across regions, with the eastern region significantly more developed than the western region. Among China's provincial-level administrative units, the eastern coastal provinces of Jiangsu, Zhejiang, and the economically strong southern province of Guangdong are leading in digital trade development. At the same time, the municipalities of Beijing and Shanghai also perform outstandingly. Especially Guangdong Province, which leads the nation in overall digital trade development and has been at the forefront for seven consecutive years. In stark contrast, the central and western regions have relatively slower digital trade development. For example, provinces such as Yunnan, Guizhou, Gansu, Shanxi, and Henan are significantly behind in digital trade development and are at a clear disadvantage compared to the southeastern coastal regions.

China's digital economy development encounters challenge due to insufficient R&D investment and weak core technologies. According to the "China Statistical Yearbook," the internal expenditure on research and experimental development by Chinese manufacturing enterprises was 2179.97 billion yuan in 2019 and 2351.42 billion yuan in 2020, showing a year-on-year increase of 7.86%, accounting for only 2.29% of regional GDP. It is clear that although China has established a foundational infrastructure for the digital economy, the total investment in digital technology remains inadequate, the level of R&D investment is low, and the growth rate is slow. Insufficient R&D investment diminishes the innovation capabilities of many manufacturing enterprises. This lack of innovation may lead to a deficit of key technologies in emerging industries such as integrated circuits, chip

manufacturing, and blockchain. Digital core technologies are essential for the digital transformation of manufacturing enterprises. However, "bottleneck" issues in core technologies and key areas impede the drive for digital transformation in manufacturing. Furthermore, in 2020, the global industrial digital transformation rate reached 28.3%. Comparatively, the penetration rate of the digital economy in Chinese manufacturing is not high, hindering the digital and intelligent transformation of manufacturing. Many traditional manufacturing industries were established early and still operate under older models that emphasize production factors like labor and capital. The management of these enterprises tends to lag in strategic awareness and management levels, with insufficient understanding of industrial digital transformation and a lack of strong proactive transformation awareness and willingness. This significantly impedes the digital transformation of manufacturing enterprises.

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Innovative UAV solutions for pollution detection and security enhancement

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Abstract

This paper aims to introduce the D4SPAs project that focuses on developing an advanced Unmanned Aircraft System (UAS) with VTOL capabilities, equipped with electrochemical, hyperspectral and optical sensors. The primary objective is to monitor and detect pollution sources and illegal activities in ports and anchorages, enhancing port operations' efficiency and sustainability. The project builds on prior research in UAV technologies, environmental monitoring, and smart port management, expanding upon recent advancements in drone-based surveillance, sensor integration, and IoT applications for maritime settings. It integrates key findings from the fields of pollution monitoring, UAV stability, and smart logistics, extending these concepts by incorporating state-of-the-art sensors for more comprehensive situational awareness in challenging port environments.The final products and services of the D4SPAs project will emphasize the efficiency of UAV-based security surveillance and pollution source detection. The project aims to evaluate the effectiveness of real-time monitoring for vessel traffic management and assess the utility of inspecting and securing port facilities. The system is designed to combat illegal activities, aid in search and rescue operations, and update port databases. These efforts will enhance decision-making, save resources, and protect the environment, addressing critical gaps in pollution and security surveillance. This solution targets the root causes of environmental degradation in port marine environments, with a focus on safety and security. Specifically, it enables stakeholders to adhere to air quality guidelines, detect plastic and marine pollution, and address phenomena such as acidification and eutrophication. Additionally, it contributes to local disaster risk reduction strategies and positively impacts marine ecosystem services. D4SPAs project solution offers a unique contribution by combining cutting-edge UAV technology with environmental monitoring, providing a ready-to-fly solution that promotes operational efficiency and environmental sustainability in port operations.

Keywords: VTOL, drone surveillance, sensor networks, ports and anchorages, environmental sustainability

1. Introduction

Sea ports are the backbone of the global economy and play an essential role in international trade. Many ports worldwide are turning to automation to increase efficiency and improve their operations to keep up with technological advancements [1]. As such, the concept of "smart ports" has recently become more focused. The smart port market is anticipated to expand rapidly at a rate of 24.3%, from an expected 1.9 billion in 2022 to a total value of 5.7 billion USD by 2027 [2]. This evolution will be feasible only with the further application of intelligent solutions such as big data analytics, artificial intelligence (AI), Internet-of-Things (IoT), and more to the seaport environment. Unmanned aerial vehicle (UAV), most often referred to as drones, is an aircraft that is controlled remotely or autonomously and contains sensors, target designators, offensive weapons, or electronic transmitters with an intended target objective [3]. These target objectives could focus on areas such as remote sensing [4, 5], construction and infrastructure inspection [6, 7], civil engineering [8, 9], search and rescue operations [6, 7, 4], military applications [10, 11], and more. UAVs can be astonishingly effective, delivering significantly more range and endurance than equivalent manned systems since they are not constrained by a crew, life-support equipment, or the design-safety standards of manned aircraft [12]. Due to their versatility, standoff capability, and ease of deployment, unmanned aerial vehicles (UAVs) are being used in a wide range of military and civilian applications [13, 14]. UAVs have recently seen significant growth and investment. By 2025, it is anticipated that UAVs, will generate annual sales of more than $82.1 billion [15].

Despite the popularity, media attention and the expressed market interest, drone applications are currently limited to the testing of pilots to verify its utility in different scenarios and operations. Conclusions show that they improve security, speed, effectiveness and capacity of response and that they are indispensable for the development of a smart port, but a holistic implementation of sensors in a single UAV platform has not found an exit to this early market yet.

Although various early efforts, measurement and control of environmental aspects, detection of contamination, tracking and monitoring environmental breachers still remains a big issue for large & medium sized ports, anchorages and surrounding areas. Even though there are existing products for fume and oil spill detection, security and surveillance tasks and emergency monitoring, we aim to develop a new platform that can accomplish all these tasks with state-of-the-art technology and expand its usage to new fields of interest satisfying the environmental and security needs of port authorities.

The article aims to present the concept of a product that consists of a UAS (Unmanned Aircraft Systems) with VTOL (vertical take-off and landing) capability equipped with the appropriate sensors (electrochemical-hyperspectral-optical) used to inspect pollution sources (e.g. oil spills, emissions, waste) in a port and in a broader anchorage area. The UAS's other tasks would be to monitor and detect various illegal activities (e.g. intruder's detection, marine pollution crime), used for day and night security surveillance tasks, and deployed during emergency situations (e.g. accidents) providing real-time feed from the incident to the appropriate port or other authorities.

The proposed solution can identify activities and provide accurate and localized knowledge of incidents, security threats or possible dangers. The drone platform will be equipped with three different payloads according to the needs of the operator, while after the mission it lands reliably back on a pre-designated space. Video and imagery would be communicated to the user in real-time while other raw data could be accessed by onboard computing processing units or even after the drone returns to land with a post processing workflow. Insights about the current environmental, security or emergency situation can be extracted in an automated or semi-automated way informing the operators in real-time.

The article is structured as follows: Section 1 introduces the main purpose of the article, Section 2 explores already existing technologies and solutions related to UAV systems for pollution detection and security enhancement for ports and anchorages areas. Section 3 outlines the concept of the solution which will be developed in the project D4SPAs and finally, Section 4 concludes the article.

2. Related work

The current state of port security and environmental monitoring predominantly relies on fixed-place sensors, primarily optical, positioned at various critical locations. Ports typically employ an extensive network of cameras to oversee port areas, supplemented by manned patrolling vessels to cover broader sea regions. These systems are monitored around the clock by command centers staffed with personnel, necessitating multiple crews for continuous surveillance. The integration of drones represents a key element when speaking of technological advancements transforming ports worldwide, driven by the rapid growth of globalization and e-commerce. Despite their rising popularity, significant media coverage, and clear market interest, their practical application remains largely confined to pilot tests aimed at assessing their utility in various scenarios and operations. Findings from these trials highlight the drones' ability to enhance security, responsiveness, efficiency, and operational speed, emphasizing their critical role in the evolution of smart port ecosystems.

However, the comprehensive integration of multiple sensors into a single UAV platform has yet to achieve full-scale market adoption.

Nearest state-of-the-art solutions rely on the abundance of fixed-place sensors (mostly optical) in various critical locations. Most ports use cameras to monitor most of the port areas combined with multiple manned patrolling vessels in the broader sea area. A command centre and personnel to monitor all of the cameras in real time, 24/7 is required.

Multiple crews must be paid to provide round-the-clock monitoring of these cameras and deployment of manned vessels. This old approach has seen only some technological improvements of the means and their capabilities over the time. The involvement of human factors is crucial in interpreting a possible threat, accident or a situation and accordingly act to give the appropriate alert. However, manned operations are increasingly expensive, often limited by weather and water conditions and prone to human errors such as fatigue or miscommunication. These limitations challenge the ability of port authorities to provide frequent, efficient and effective inspection and surveillance means.

Recent players in implementing UAVs providing aerial situational awareness beyond the shoreline for purposes of vessel navigation and security is a Tel Aviv-based company, UAV Airobotics but they do not adequately describe the way the solution operates and effectively tackles the problem and operational tasks, neither technical specifications and general system properties [16]. Other notable collaborations include the Port of Antwerp working with the European Maritime Safety Agency (EMSA) and aerospace firm Sabca, the Port of Rotterdam partnering with Dutch UAV company Avy [17], and the Port of Barcelona exploring drone technology in its innovation initiatives [18].

3. D4SPAs project UAV system solution

Our remotely controlled flying platform can fly through the smoke plume of a ship and analyze how much sulfur is in the fuel in approximately 2 minutes. On their way, they can provide information for other key tasks; inspecting infrastructures, surveillance, monitoring, incident and berth management, detection of oil spills or floating waste without exposing people to danger situations as being manned from a safe distance. During surveillance, we can effectively map out an event or facility on short notice, detect potential threats and operate 24/7. All the above are tackled from competitors separately, with different technological available means while we use a single UAV platform that only by that attribute is positively affecting economies of scale, through the financials of a port and anchorage management. Our product supports the creation of an overall healthier environment that improves the life conditions of surrounding communities and has a positive impact on their economy with less health problems and relevant expenses, clean waters, more fish stocks by reducing direct and indirect environmental degradation.

The main technological challenge of this solution is the digital transformation of a port and its anchorage areas. By integrating the technology of robotics with sensors, and use of open source software with communication protocols that allow fast and secure data link, we automate various port inspection and surveillance tasks. Another challenge is the compliance of the solution regarding port security protocols and legal framework. Great emphasis is given in integration of the solution into an automated 'workflow' that is embedded into the processes and activities of the port, following possible flight-restrictions, avoiding high moving structures like cranes, towers etc. or avoiding the flight over crowded areas. Combining drone technology and sensors with situational awareness capabilities in ports, harbors or vast harbor areas, constitutes a powerful tool for the emerging industries of blue growth towards digital transition, safer ports and a healthier environment and maritime ecosystem. This innovative approach promotes efficiency, sustainability in ports and helps protect marine environments. It helps in decreasing the risk of pollution in the environment, ensuring protection to health of citizens who could be affected and safeguarding marine food supply chains (from oil spills for example). The utilization of the UAS will enable the identification of ships that were sailing in the eventual incidents area and processing of the collected data can help avoid environmental, financial and reputational risks to ports.

4. Conclusions

The UAV system solution presented in this article represents a major leap in integrating UAV technology into port operations. By introducing a cutting-edge Unmanned Aircraft System (UAS) with VTOL capabilities, the initiative addresses critical challenges in environmental monitoring, pollution detection, and security within port settings.

This innovative approach provides port authorities with a powerful tool to enhance operational efficiency, ensure adherence to environmental standards, and respond swiftly to emergencies, significantly improving the sustainability and safety of port activities.

Acknowledgements

This work has been supported in part by UEFISCDI Romania and MCI through projects D4SPAs (EUROSTARS-3-E!2714-D4SPAs) and European Defense Funding through lump sum project, grant agreement no.101121412 — PASITHEA.

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e-Stonia: *Sui generis* Governance

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Abstract
As of late, e-government has become an increasingly discussed issue in academia and politics. The whole world has turned its attention to Estonia, the tiny Baltic state that has climbed to the top of global e-development, notably thanks to its e-voting system. In an attempt to catch up, the rest of the developed and developing countries, as well as researchers, have expressed interest in the reliability of the Estonian model of e-government but also in the ease and speed with which such a model of digitalisation could be implemented. This article uses the case study method and follows precisely the arguments, counter-arguments, and, of course, the evidence that has been brought to the table, either for or against the *e-Stonian* model, as reflected in research previously published in several academic journals. This article concludes that the Estonian system is characterised by safety and effectiveness, having been implemented relatively quickly and without particular difficulties. Thus, the Estonian model is a model worth following for global policymakers. The paper adds value to the academic setting in which it was written by bringing up to date the development of the Estonian e-government system and highlighting crucial aspects that other countries can take up in their digitalisation of the public system.

Keywords: e-governance, e-vote, digitalisation.

1. Introduction
In recent decades, social science academia has shown a growing interest in electronic governance [1, 2]. Digitalisation of vital public sector functions is a global trend that affects not only highly industrialised countries but also developing ones. In this respect, Estonia leads the world in digitalising government [1]. Electronic governance refers to the use of information and communication technology (ICT) in the public sector [1, 2], combined with organisational change and the development of new skills needed to improve public services and democratic processes in order to strengthen support for public policies [2], and encompasses the digitalisation of governmental archives, national data, as well as communication between government, public administration and citizens, thus being a technology-enabled public policy. Governments have increasingly turned to e-governance in recent times because digital tools are now readily available and also because public administration and politicians are beginning to understand its benefits when it comes to efficiency [1].

This article employs the case study research method and commences from two research hypotheses: the first is that Estonia's e-government system is secure and efficient, and the second is that its implementation has been relatively straightforward and rather quick. After presenting Estonia's background and specifics in terms of its electronic government, the article analyses in detail the most remarkable component of Estonian e-government, namely the electronic voting system, before presenting the concluding remarks.

2. Estonia and electronic governance

The popularisation of the Internet in the mid-1990s coincided with a significant increase in the use of e-government tools by local, federal or national governments in European countries, the purpose of which was to deliver information, communication and various other electronic services to citizens, many of which are now available exclusively digitally. With the transformation of electronic government into a dynamic socio-technical system concerned with issues of governance, social trends, technological change, information management, interactions and the human factor, it has been recognised that one of the most essential benefits of e-government is that it brings the citizen closer to government [3].

Estonia is a Baltic country with a population of about 1.4 million. It gained its independence from the Soviet Union in 1991. Its transition from communism to democracy is often considered to be one of the most successful in the former communist bloc of Europe. Although it has drawn some criticism [2, 4], Estonia's remarkable success in promoting a technology-based information society is widely accepted, particularly in establishing the principles of e-governance [2]. In this respect, Estonia is at the top of various global rankings [2, 4].

Factors behind the success of Estonian electronic government include adequate public sector leadership skills, adequate funding, legislative and regulatory support, development of strategic ICT infrastructure, successful public-private partnerships and private sector skills [2]. The success of the electronic voting system is based on four key features of the Estonian experience: the widespread availability of the Internet, the legal structure that addresses e-voting issues, the identification system that allows digital authentication of the voter, and the political culture that supports e-voting [5].

The Estonian e-government model is based on transparency and accountability: most user data is openly available to government institutions, and Estonian citizens can track every request for their data and have the right to ask for clear justifications for its use. The Estonian model works well because every citizen has a digital identity and an electronic signature. All public requests can be processed securely and efficiently through the X-Road without too much administrative hassle for citizens and officials. Estonia's exemplary e-governance model suggests that electronic government has a high success rate in small countries with a young population, a high level of trust in institutions and a need for constant technological renewal [6].

When it comes to Estonia, the introduction of e-governance should be understood as part of a general investment in advanced technology after the collapse of the Soviet Union and the regaining of independence [1]. Even though Estonia has never had a governmental strategy aimed at e-governance [4], it has been developed due to the close cooperation between the private sector and public interests, spearheaded by the banking system. Economic development has favoured investment in information infrastructure, but the launch of e-governance was also in line with the consolidation of democracy after a long period of authoritarian alien rule, and the electronic government, of course, fit like a glove with Estonia's transition from a former communist republic to a modern, democratic

European state [1]. Thus, although the governmental implementation of e-governance was carried out without specific documents and formal cooperation, Estonia has managed to catch up with many other countries with such governmental strategies in digitalising their governance [4].

Since gaining independence in 1991, Estonia has succeeded in developing a fully functioning and secure e-state. IT solutions developed for state-building constitute a part of the country's government administration. IT is used to enhance administrative capacity and provide an innovative and convenient environment for citizens and businesses. In Estonia, almost all citizens pay their taxes electronically, a process that takes less than five minutes. Registering companies online takes about 18 minutes, while annual financial reports can be submitted electronically. Therefore, since almost everything has started to migrate to the electronic sphere in "e-Stonia", it was only natural that the voting system would too [7].

The critical moment for prioritising the IT environment in Estonia came in 1999 with the appointment of Mart Laar as prime minister. Although, at the time, the political opposition and the general public were against the introduction of electronic identity cards (eID cards), Laar ignored the critics and continued to push for the implementation of the measure. In 2001, X-Road, a government database link, was introduced. Instead of developing a single, all-encompassing central system, Estonia preferred to create an open and decentralised system connecting various services and databases. X-Road combines technical, legislative and organisational frameworks that enable government-wide interconnectivity. All Estonian electronic solutions that require interaction with multiple databases use X-Road [4, 7]. In 2002, Estonia introduced the eID as the primary document for identifying citizens and residents of the country. In addition to being a physical identification document, the eID also contains advanced electronic functions that facilitate secure authentication and a mandatory digital signature for the use of online services throughout the country. Today, more than 600 public and private information systems and the more than 2.600 services they offer are part of the state administration information system. Some 44 million digital signatures have been processed in Estonia in the first decade since the system's launch, with over 40.000 digital signatures being processed nationwide every day. The decisions taken by Mart Laar two decades ago were undoubtedly the basis for the subsequent success of *e-Stonia*. Today, Estonia is certainly one of the global leaders in e-government, setting a benchmark for many of the world's developed and developing countries [7].

However, Estonian e-government predictably has its weaknesses. Perhaps the most important of these is the lack of initiative on the part of the *e-Stonian* government in providing services that could encourage electronic participation and digital democracy. This is a clear indication that the Estonian government is only coming up with initiatives in this regard in response to requests from the private sector and the general public, but also that these initiatives have only been implemented in areas where transaction costs were lowest [4].

3. Estonia's electronic voting system

The Estonian e-voting system was first used for local council elections in 2005 to increase voter turnout by simplifying the electoral process, and it was a real success. Two years later, it was also made available for parliamentary elections [2, 4, 5, 7, 8], and two years later, it was also used in the European Parliament elections [2, 8], all these occasions becoming world firsts [7]. Electronic voting allows registered voters to cast their vote via any internet-connected device from anywhere in the world without having to go to a polling station [2, 7, 9]. It is not intended to replace the traditional voting method but to complement it. In the run-up to the election, the voters authenticate themselves in the e-voting system using an eID and then register their vote. The voter's identity is then removed from the digital ballot before it reaches the National Election Commission (NEC) for counting, thus ensuring the anonymity of the vote [7].

From the Estonian voter's perspective, the e-voting procedure is as follows:

1. They enter their eID into a card reader and open the voting webpage;
2. Their identity is verified using the first pin code of the eID;
3. The server checks if they are eligible using the population register data;
4. The voters are shown the list of candidates according to the electoral district;
5. They decide to whom they give their vote, which is then encrypted;
6. The voters then confirm their choice with a digital signature by entering the second eID pin code;
7. The digital signature is removed from the e-vote before it reaches the NEC so that NEC members can finally open the anonymised e-votes for counting [7, 9].

Electronic voting is only possible a week before election day, a time frame allocated explicitly for this purpose between the tenth and the fourth day before election day. This security measure is necessary to ensure that only one vote is counted for each voter. The list of those who have voted electronically is then drawn up and sent to the polling stations so their observers are notified of who has already voted. This measure, therefore, prevents those who have voted electronically from voting again physically. In order to ensure that the voter expresses their real voting intention, they are allowed, in the week before the elections, to change their vote either by casting a new electronic vote or by casting a physical vote, which has priority [2, 5, 7, 9]. If the voter chooses to vote physically, their electronic vote is deleted. However, the registered electronic vote cannot be changed or deleted on election day. For example, in the 2011 elections, according to official data, 3% of voters who chose to vote electronically changed their voting preferences and voted more than once. However, it has yet to be known how and when they changed their vote, and it is impossible to identify with certainty a link in terms of last-minute changes in e-voting as a result of election campaigns or news.

Electronic voting has raised many questions about its security. From a technical point of view, thanks to the existing X-Road and eID system, e-voting is just another application of eID with some specific requirements. The system authenticates the users via the eID, and then they confirm their vote with a digital signature. E-voting can be compared to any other similar procedure where a digital signature is required: banking transactions, setting up a

company, querying the commercial register, sending notarised documents, signing contracts and so on. The main trust issues facing e-voting are, on the one hand, trust in the central system, i.e. the eID, and, on the other hand, human error. In Estonia, however, the central system has proven reliable for over two decades. In defence of using the devices to vote, it is often argued that those who would have the knowledge, resources and access to infiltrate the devices to a large number of voters would have no reason to do so, but also that political forces that would have the necessary motivation could not afford to take the risks associated with such interference. For example, people who conduct business and financial transactions using their devices expose themselves to considerably more significant daily risks than during electronic voting.

The electronic voting system is becoming increasingly popular, and the number of people using it is also steadily increasing, as is the number of countries from which e-voting is used in Estonian elections. Moreover, it enables the Estonian diaspora to participate actively in politics at home [7]. It should be noted that voting is not compulsory in Estonia [5, 7], but also that the number of potential voters in local elections, where residents can also vote, differs from parliamentary elections, where only citizens can vote [7]. The statistics also show that right-wing parties are the primary beneficiaries of e-voting [7, 8], that there are no significant differences between age groups in the use of e-voting [5, 7], and that women use e-voting more than men. While electronic voting takes an average of six minutes, physical voting takes an average of 44 minutes. Thus, e-voting obviously reduces the time and costs associated with the voting process, as confirmed by the 75% of those who preferred e-voting to the traditional method. Although cost containment was not the main objective, it only goes to show once again that electronic services save both citizens and institutions unnecessary time and money [7].

In the parliamentary elections, the most important for the small Baltic state, the percentage of those who preferred electronic voting rose from 6% in 2007 to 31% in 2015 [8, 9]. Voter turnout has also increased from 58% in 2003, the last year elections were held offering only the traditional voting method, to 64% in 2015 [8]. Although other factors influenced the increase in turnout, e-voting has been shown to increase it [4, 8] or at least prevent turnout from falling. This is also confirmed by the 10-15% of e-voters who stated that they would not have voted at all if the electronic option had not been available and that their turnout depended on the availability of the digitally enabled voting method. Moreover, statistics show that e-voting retains users better than traditional voting. While 80% of e-voters said they would vote online in the next two elections, only 60% of those who preferred the traditional method said they would continue to use it [8].

Another interesting aspect of e-voting in Estonia is that demographic differences in the elections have been rapidly blurring. While in 2007 and 2011, first-time electronic voters in parliamentary elections were more likely to be ethnic Estonians with higher education and aged between 35 and 45, in the 2015 parliamentary elections, these demographic trends were no longer valid: both ethnic Estonians and ethnic Russians, regardless of their education, financial status or age were equally likely to vote electronically [8, 9]. Moreover, not even computer literacy, which in the past had been a strong indicator of e-voting

tendencies, seemed to matter anymore: even people who considered themselves to have low computer literacy were just as likely to vote electronically as those who rated their computer literacy as high. This strongly indicates that e-voting has moved beyond the initial stage of being embraced only by a small, elite group of early adopters and has become popular among large masses of the population [8].

4. Concluding remarks

The conclusions are clear: technology has the potential to bridge social divides and facilitate political participation, not only for those already connected and with available resources, but also for the less privileged, those with fewer resources and who remain on the periphery of the use of modern technologies. Similarly, e-voting appeals to those who find the conventional method burdensome. As a more convenient voting method, e-voting can also facilitate the participation of those who are connected and engaged but may still decide to abstain due to the inconvenience of conventional voting. The experience of using e-voting in Estonia demonstrates that technology should not be seen as an obstacle but as a promoter of political participation. However, it should be noted that technology only provides efficient participation. Thus, the structural obstacles to participation in general, regardless of the voting method chosen, will remain intact. Despite critical voices, however, technology does not exclude anyone.

Time is also crucial regarding the results: the electoral effects did not manifest immediately after introducing the new voting technology. However, they took a minimum of three electoral processes to become evident. Of course, a select group with the resources and skills to use the new technologies adopted and used e-voting immediately. However, for the general public, the benefits can only be seen once the technologies have spread, which takes time. Policy-makers should be advised to avoid expecting immediate results from introducing new voting technologies but to recognise that different parts of the electorate adopt and use new technologies at different rates. The good news is that this has proved to be a relatively quick process, provided that it is not just time that is a factor in the spread of technology use but also exposure to more elections where the technologies are available [9]. Thus, both research hypotheses from which this paper started have been confirmed, with the Estonian e-government system proving to be secure and efficient and relatively easy and fast to implement.

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e-Stonia: Guvernare sui-generis

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Abstract
În ultimul timp, guvernarea electronică a devenit o problemă din ce în ce mai discutată atât în mediul academic, cât şi în cel politic. Astfel, întreg mapamondul şi-a îndreptat atenţia asupra Estoniei, micuţul stat baltic care a reuşit să se caţere până în vârful dezvoltării electronice la nivel global, în special graţie sistemului său de vot electronic. În încercarea de a o ajunge din urmă, restul statelor, fie ele dezvoltate sau în curs de dezvoltare, dar şi cercetătorii, şi-au exprimat interesul cu privire la fiabilitatea modelului estonian de guvernare electronică, dar şi cu privire la uşurinţa şi rapiditatea cu care ar putea fi implementat un astfel de model de digitalizare. Acest articol foloseşte metoda studiului de caz şi urmăreşte întocmai argumentele, contraargumentele şi, bineînţeles, dovezile care au fost aduse în acest sens, fie pentru sau împotriva modelului *e-Stonian*, aşa cum reies din cercetările publicate anterior în mai multe jurnale academice. Concluzia acestui articol este aceea că sistemul estonian este caracterizat prin siguranţă şi eficacitate, fiind implementat relativ rapid şi fără dificultăţi deosebite. Astfel, modelul oferit de Estonia este unul demn de urmat pentru factorii decizionali la nivel global. Lucrarea adaugă valoare în cadrul academic în care a fost redactată prin faptul că aduce la zi dezvoltarea sistemului estonian de guvernanţă electronică şi pune în evidenţă aspectele cruciale care pot fi preluate şi de alte state în procesul lor de digitalizare a sistemului public.

Cuvinte-cheie: guvernare electronică, vot electronic, digitalizare.

1. Introducere
În ultimele decenii, mediul academic din sfera ştiinţelor sociale a demonstrat un interes în creştere faţă de problema guvernării electronice [1] [2]. Digitalizarea funcţiilor vitale ale sectorului public este o tendinţă globală care afectează nu doar ţările puternic industrializate, ci şi pe cele care se află în curs de dezvoltare. În acest sens, Estonia se află în fruntea statelor lumii în ceea ce priveşte digitalizarea guvernării [1].

Guvernarea electronică se referă la utilizarea tehnologiei informaţiilor şi comunicaţiilor (TIC) în sectorul public [1], [2], combinată cu schimbarea organizaţională şi dezvoltarea noilor aptitudini necesare îmbunătăţirii serviciilor publice şi proceselor democratice, în vederea consolidării susţinerii pentru politicile publice [2], şi cuprinzând digitalizarea arhivelor guvernamentale, a datelor naţionale, cât şi a comunicării dintre guvern, administraţia publică şi cetăţeni, fiind, astfel, o politică publică bazată pe tehnologie. În ultima vreme, guvernele apelează din ce în ce mai mult la guvernarea electronică deoarece instrumentele digitale sunt acum la îndemână, dar şi pentru că administraţia publică şi politicienii încep să înţeleagă avantajele aduse de aceasta la nivelul eficienţei [1].

Acest articol foloseşte metoda studiului de caz şi porneşte de la două ipoteze de cercetare: prima este că sistemul de guvernare electronică din Estonia este unul sigur şi eficient, cea de-a doua fiind faptul că implementarea sa a fost una relativ facilă şi rapidă. După prezentarea istoricului şi specificului Estoniei în ceea ce priveşte guvernarea electronică, articolul analizează în detaliu cea mai remarcabilă componentă a guvernării electronice estoniene, şi anume sistemul de vot electronic, înainte de a prezenta concluziile care îl conchid.

2. Estonia şi guvernarea electronică

Popularizarea Internetului la mijlocul anilor ’90 a coincis cu o creştere semnificativă a utilizării instrumentelor guvernării electronice de către guvernele locale, federale sau naţionale ale ţărilor europene, scopul acestora fiind de a livra informaţii, mijloace de comunicare şi alte diverse servicii electronice către cetăţeni, multe dintre ele fiind acum disponibile exclusiv digital. Odată cu transformarea guvernării electronice într-un sistem sociotehnic dinamic care se preocupă de probleme ce ţin de guvernare, tendinţe sociale, schimbări tehnologice, administrarea informaţiilor, a interacţiunilor şi a factorului uman, s-a constatat faptul că unul dintre cele mai importante beneficii ale guvernării electronice este acela că aceasta din urmă aduce mai aproape cetăţeanul de guvernare [3].

Estonia este o ţară baltică cu o populaţie de aproximativ 1.4 milioane de locuitori, care şi-a obţinut independenţa faţă de Uniunea Sovietică în anul 1991, tranziţia ei de la comunism la democraţie fiind adesea considerată a fi una din cele mai de succes din fostul bloc comunist european. În ciuda vocilor critice [2] [4], succesul remarcabil al Estoniei în promovarea unei societăţi informaţionale bazate pe tehnologie este general acceptat, în special în ceea ce priveşte instituirea principiilor guvernării electronice [2]. Din acest punct de vedere, Estonia se situează în fruntea diverselor clasamente la nivel mondial [2], [4].

Printre factorii care au stat la baza succesului guvernării electronice estoniene se numără competenţele adecvate ale conducerii sectorului public, finanţarea adecvată, susţinerea legislativă şi de reglementare, dezvoltarea infrastructurii strategice a TIC, parteneriate de succes între mediul public şi cel privat, dar şi competenţele sectorului privat [2]. În ceea ce priveşte succesul sistemului de vot electronic, acesta se bazează pe patru caracteristici-cheie ale experienţei estoniene: disponibilitatea pe scară largă a Internetului, structura legală care adresează problemele legate de votul electronic, sistemul de identificare care permite autentificarea digitală a alegătorului, dar şi cultura politică care susţine votul electronic [5].

Modelul estonian de guvernare electronică se bazează pe transparenţă şi responsabilitate: majoritatea datelor utilizatorilor sunt disponibile în mod deschis instituţiilor guvernamentale, iar cetăţenii estonieni pot urmări fiecare solicitare a datelor lor şi au dreptul de a cere justificări clare pentru folosirea acestora. Modelul estonian funcţionează bine deoarece fiecare cetăţean are propria identitate digitală şi o semnătură electronică. Prin intermediul X-Road, toate solicitările publice pot fi procesate în mod sigur şi eficient fără prea multe bătăi de cap administrative, atât pentru cetăţeni, cât şi pentru funcţionari. Modelul exemplar de guvernare electronică oferit de Estonia sugerează faptul că guvernarea electronică are o rată de succes ridicată în ţările mici, cu o populaţie tânără, care are un nivel ridicat de încredere în instituţii şi care necesită o reînnoire tehnologică permanentă [6].

În cazul Estoniei, introducerea guvernării electronice trebuie înţeleasă ca fiind parte a unor investiţii generale la nivelul tehnologiei avansate după colapsul Uniunii Sovietice şi redobândirea independenţei [1]. În ciuda faptului că Estonia nu a avut niciodată o strategie guvernamentală privind guvernarea electronică [4], aceasta a fost dezvoltată în urma unei strânse cooperări între mediul privat şi interesele publice, în fruntea căreia a stat sistemul

bancar. Dezvoltarea economică a favorizat investiţiile în infrastructura informaţională, însă lansarea guvernării electronice s-a aliniat şi procesului de consolidare a democraţiei după o lungă perioadă de conducere venetică autoritară, guvernarea electronică potrivindu-se, bineînţeles, ca o mănuşă tranziţiei estoniene de la o fostă republică comunistă la un stat european modern şi democratic [1]. Astfel, deşi implementarea guvernamentală a guvernării electronice a fost realizată fără documente specifice şi fără cooperare formală, Estonia a reuşit să ia faţa multor alte state care au avut astfel de strategii guvernamentale în ceea ce priveşte guvernarea electronică [4].

De la obţinerea independenţei în 1991, Estonia a reuşit să dezvolte un stat electronic complet, funcţional şi sigur. Soluţiile din mediul IT, dezvoltate pentru construirea acestui stat, constituie o parte din administraţia guvernamentală a acestei ţări. Mediul IT este utilizat pentru a spori capacitatea administrativă şi pentru a asigura un mediu inovativ şi convenabil atât pentru cetăţeni, cât şi pentru afaceri. În Estonia, aproape toţi cetăţenii îşi plătesc taxele electronic, un proces care durează mai puţin de cinci minute. Înregistrarea companiilor online durează aproximativ 18 minute, în timp ce rapoartele financiare anuale pot fi, de asemenea, trimise electronic. Ori din moment ce aproape totul a început să migreze spre sfera electronică în „e-Stonia", era firesc ca acelaşi lucru să se întâmple şi cu sistemul de vot [7].

Momentul-cheie pentru prioritizarea mediului IT în Estonia a venit în anul 1999, odată cu numirea lui Mart Laar în funcţia de prim-ministru. Deşi, la acea vreme, opoziţia politică şi publicul larg se opuneau introducerii cărţilor de identitate electronice (CIE), Laar a ignorat vocile critice şi a continuat să se zbată pentru implementarea acestei măsuri. În anul 2001 a fost introdus X-Road, o conexiune a bazei de date guvernamentale. În locul dezvoltării unui sistem central unic şi atotcuprinzător, Estonia a preferat să creeze un sistem deschis şi decentralizat care conectează diverse servicii şi baze de date. X-Road este o combinaţie de cadre tehnice, legislative şi organizaţionale care permit interconectivitatea la nivel guvernamental. Toate soluţiile electronice estoniene care necesită interacţiunea cu baze de date multiple folosesc X-Road [4], [7] În anul 2002, Estonia a introdus CIE drept document principal pentru identificarea cetăţenilor şi a rezidenţilor din ţară. Pe lângă faptul că este un document fizic de identificare, CIE conţine şi funcţii electronice avansate care facilitează autentificarea sigură şi o semnătură digitală obligatorie, în vederea folosirii serviciilor online la nivelul întregii ţări. Astăzi, peste 600 de sisteme informaţionale publice şi private, împreună cu cele peste 2.600 de servicii pe care le oferă, fac parte din sistemul informaţional al administraţiei de stat. Aproximativ 44 de milioane de semnături digitale au fost procesate în Estonia în primul deceniu de la lansarea acestui sistem, realizându-se peste 40.000 de astfel de semnături în fiecare zi la nivel naţional. Deciziile luate de Mart Laar în urmă cu două decenii au stat în mod evident la baza succesului ulterior al *e-Stoniei*. Astfel, în prezent, Estonia este liderul global detaşat în sfera guvernării electronice, reprezentând un punct de reper din acest punct de vedere pentru multe dintre ţările lumii, fie ele dezvoltate sau în curs de dezvoltare [7].

Cu toate acestea, guvernarea electronică estoniană are, în mod previzibil, şi puncte slabe. Poate că cel mai important dintre ele este lipsa iniţiativei din partea guvernului *e-Stonian* în ceea ce priveşte furnizarea de servicii care ar putea încuraja participarea electronică şi

democraţia digitală. Acest lucru indică în mod clar faptul că guvernul *e-Stoniei* vine cu iniţiative în acest sens doar ca reacţie la solicitările sectorului privat şi a publicului larg, dar şi că aceste iniţiative au fost implementate doar în zonele în care costurile tranzacţionale erau cele mai scăzute [4].

3. Sistemul de vot electronic în Estonia

Sistemul estonian de vot electronic a fost folosit pentru prima oară în anul 2005, în cadrul alegerilor pentru consiliile locale, cu intenţia de a creşte rata participării la vot prin simplificarea procesului electoral, fiind un real succes. Doi ani mai târziu, acesta a fost făcut disponibil şi pentru alegerile parlamentare [2], [4], [5], [7], [8] iar peste doi ani a fost utilizat şi în cadrul alegerilor europarlamentare [2], [8] toate aceste ocazii devenind premiere la nivel mondial [7]. Votul electronic le permite alegătorilor înregistraţi să voteze prin intermediul oricărui dispozitiv conectat la Internet, de oriunde din lume, fără a fi nevoiţi să se deplaseze la o secţie de vot [2], [7], [9]. Acesta nu este menit să înlocuiască metoda tradiţională de vot, ci să o complinească. În perioada stabilită premergătoare alegerilor, votantul se autentifică în cadrul sistemului de vot electronic folosind CIE, după care îşi înregistrează votul. Identitatea alegătorului este apoi înlăturată din votul digital înainte ca acesta să ajungă la Comisia Electorală Naţională (CEN) pentru numărătoare, astfel asigurându-se anonimitatea votului [7].

Din perspectiva alegătorului estonian, procedura votului electronic este următoarea:

- Acesta îşi introduce CIE într-un cititor de carduri şi deschide pagina web pentru vot;
- I se verifică identitatea folosind primul cod pin al CIE;
- Serverul verifică dacă alegătorul este eligibil, folosind datele registrului populaţiei;
- Alegătorului îi este prezentată lista candidaţilor conformă districtului electoral;
- Acesta decide cui îi oferă votul, care este apoi criptat;
- Apoi, votantul îşi confirmă alegerea cu o semnătură digitală prin introducerea celui de-al doilea cod pin al CIE;
- Semnătura digitală este înlăturată din votul electronic înainte ca acesta să ajungă la CEN, astfel că, în final, membrii acesteia pot deschide voturile electronice anonime pentru efectuarea numărătorii [7], [9].

Votul electronic este posibil doar într-o săptămână premergătoare zilei alegerilor, alocată special între a zecea şi a patra zi dinaintea celei din urmă. Această măsură de siguranţă este necesară pentru a garanta faptul că doar un singur vot este numărat pentru fiecare alegător. Lista celor care au votat electronic este întocmită şi trimisă apoi secţiilor de vot, observatorii acestora fiind, astfel, înştiinţaţi cu privire la cine a votat deja. Această măsură îi împiedică, prin urmare, pe cei care au votat electronic să mai voteze încă o dată şi fizic. Pentru a se asigura că alegătorul îşi exprimă intenţia de vot reală, acestora li se permite, în săptămâna premergătoare alegerilor, să îşi schimbe votul fie printr-un nou vot electronic, fie prin votul fizic, care are prioritate [2], [5], [7], [9]. Dacă alegătorul alege varianta votului fizic, votul său electronic este şters. În ziua alegerilor, însă, votul electronic înregistrat nu mai poate fi schimbat sau şters. Spre exemplu, în cadrul alegerilor din 2011, conform datelor oficiale, 3% dintre alegătorii care au preferat votul electronic şi-au schimbat

preferinţele electorale, votând mai mult decât o dată. Cu toate acestea, nu se ştie cum şi când şi-au schimbat votul, nefiind posibilă identificarea cu certitudine a unei conexiuni în privinţa schimbării votului electronic în ultima clipă ca urmare a campaniilor electorale sau a ştirilor.

Votul electronic a ridicat numeroase semne de întrebare cu privire la siguranţa sa. Din punct de vedere tehnic, graţie sistemului existent al X-Road şi CIE, votul electronic este doar o altă aplicaţie a CIE, cu anumite cerinţe specifice. Sistemul autentifică utilizatorul prin intermediul CIE, iar apoi acesta îşi confirmă votul prin semnătura digitală. Practic, votul electronic poate fi comparat cu orice altă procedură similară în care este necesară semnătura digitală: tranzacţii bancare, înfiinţarea unei companii, interogarea registrului comercial, trimiterea documentelor notariale, semnarea contractelor şi aşa mai departe. Problemele principale de încredere cu care se confruntă votul electronic sunt, pe de o parte, încrederea în sistemul central, adică a CIE, şi, pe de altă parte, erorile umane. În Estonia, totuşi, sistemul central şi-a dovedit fiabilitatea de peste două decenii. În apărarea folosirii dispozitivelor pentru a vota, se invocă adesea faptul că cei care ar avea cunoştinţele, resursele şi accesul necesar infiltrării dispozitivelor unui număr mare de alegători nu ar avea niciun motiv să o facă, dar şi faptul că forţele politice care ar avea motivaţia necesară nu şi-ar putea permite asumarea riscurilor asociate unei astfel de imixtiuni. Spre exemplu, persoanele care fac afaceri şi tranzacţii financiare folosindu-şi dispozitivele se expun unor riscuri considerabil mai mari în viaţa de zi cu zi decât o fac în timpul votului electronic.

Sistemul de vot electronic devine din ce în ce mai popular, iar numărul celor care îl folosesc este, de asemenea, într-o creştere continuă, la fel ca şi numărul ţărilor din care se votează electronic în alegerile estoniene. Mai mult, acesta îi permite diasporei estoniene să participe în mod activ în politica de acasă [7]. Trebuie notat faptul că votul nu este obligatoriu în Estonia [5] [7], dar şi că numărul potenţialilor votanţi în alegerile locale, în cadrul cărora pot vota şi rezidenţii, diferă de cel al alegerilor parlamentare, în cadrul cărora pot vota doar cetăţenii [7]. Statisticile arată şi faptul că partidele de dreapta sunt principalii beneficiari ai voturilor electronice [7], [8] că nu există diferenţe majore între categoriile de vârstă privind folosirea votului electronic [5], [7] dar şi că femeile folosesc mai mult varianta electronică decât bărbaţii. Dacă votul electronic durează în medie şase minute, cel fizic durează în medie 44. Astfel, este evident faptul că votul electronic scade timpul şi costurile asociate procesului de vot, lucru confirmat şi de 75% dintre cei care au preferat această metodă în detrimentul celei clasice. Deşi limitarea costurilor nu a fost obiectivul principal, aceasta nu face decât să demonstreze încă o dată faptul că serviciile electronice scutesc atât cetăţenii, cât şi instituţiile de timp şi bani irosiţi inutil [7].

În cadrul alegerilor parlamentare, cele mai importante pentru micul stat baltic, procentul celor care au preferat votul electronic a crescut de la 6% în 2007 la 31% în 2015 [8], [9]. De asemenea, participarea la vot a crescut de la 58% în 2003, ultimul an în care alegerile s-au desfăşurat oferind doar metoda clasică de vot, la 64% în 2015 [8]. Bineînţeles că, deşi au existat şi alţi factori care au influenţat creşterea participării la vot, s-a demonstrat faptul că votul electronic a crescut rata participării la vot [4], [8] sau, cel puţin, a prevenit scăderea acesteia. Acest lucru este confirmat şi de cei 10-15% dintre votanţii electronici care au declarat faptul că nu ar mai fi votat deloc dacă opţiunea electronică nu ar fi fost disponibilă,

participarea lor la vot depinzând, prin urmare, de disponibilitatea variantei electronice a votului. Mai mult, statisticile arată că votul electronic tinde să-şi fidelizeze mai bine utilizatorii decât cel clasic: dacă 80% dintre votanţii electronici au declarat că vor vota online în următoarele două alegeri, doar 60% dintre cei care au preferat metoda clasică au declarat că vor continua să o folosească în viitor [8].

Un alt aspect interesant în ceea ce priveşte votul electronic din Estonia este faptul că diferenţele demografice s-au estompat rapid în cadrul alegerilor. Dacă în 2007 şi 2011, cei care votau pentru prima oară în format electronic în cadrul alegerilor parlamentare erau, mai degrabă, etnici estonieni cu studii superioare şi cu vârste cuprinse între 35 şi 45 de ani, la alegerile parlamentare din 2015 aceste tendinţe demografice nu mai erau valabile: atât etnicii estonieni cât şi cei ruşi, indiferent de educaţia lor, de statutul lor financiar sau de vârsta lor erau la fel de predispuşi votului electronic [8], [9]. Mai mult decât atât, nici măcar competenţele informatice, care în trecut erau un indicator puternic al tendinţelor de vot electronic, nu păreau să mai conteze: inclusiv persoanele care considerau că au competenţe informatice de un nivel scăzut erau la fel de predispuse să voteze electronic ca şi cele care îşi apreciau nivelul competenţelor informatice ca fiind unul ridicat, concluzia autorilor fiind aceea că votul electronic a depăşit etapa iniţială în care era îmbrăţişat doar de un grup restrâns, elitist de adoptatori timpurii, devenind popular în rândul marilor mase ale populaţiei [8].

4. Concluzii

Concluziile sunt clare: tehnologia are potenţialul de a trece peste diviziunile sociale şi de a facilita participarea politică, nu doar pentru cei deja conectaţi şi cu resurse disponibile, ci şi pentru cei mai puţin privilegiaţi, care dispun de mai puţine resurse şi care rămân la periferia utilizării tehnologiilor moderne. În mod similar, votul electronic îi atrage pe cei care consideră metoda convenţională ca fiind împovărătoare. Fiind o metodă de participare la vot mai convenabilă, votul electronic are, de asemenea, potenţialul de a facilita participarea celor care sunt conectaţi şi implicaţi, dar care totuşi pot decide să se abţină din cauza neplăcerilor votului clasic. Experienţa folosirii votului electronic în Estonia demonstrează faptul că tehnologia nu trebuie privită ca pe un obstacol, ci ca pe un promotor al participării politice. Cu toate acestea, trebuie notat faptul că tehnologia furnizează doar un mod eficient de participare. Astfel, obstacolele structurale care împiedică participarea în general, indiferent de metoda de vot aleasă, vor rămâne, cel mai probabil, intacte. În ciuda vocilor critice, se pare, totuşi, că tehnologia însăşi nu exclude pe nimeni.

De asemenea, este crucial aspectul timpului în privinţa rezultatelor: efectele electorale nu s-au manifestat imediat după introducerea noii tehnologii de vot, ci au avut nevoie de minim trei procese electorale pentru a deveni evidente. Desigur că un grup select, care dispunea deja de resursele şi abilităţile necesare utilizării noilor tehnologii, a adoptat şi s-a folosit imediat de votul electronic. La nivelul publicului larg, însă, beneficiile pot fi observate doar după ce utilizarea tehnologiilor s-a răspândit, ori acest lucru necesită timp. Factorii de decizie politică trebuie sfătuiţi să nu se aştepte la rezultate imediate ca urmare a introducerii noilor tehnologii de vot, ci să recunoască faptul că diferite părţi ale electoratului adoptă şi utilizează noile tehnologii în ritmuri diferite. Vestea bună este că acest proces s-a dovedit a fi unul relativ rapid, cu condiţia ca nu doar timpul să fie un factor

care contribuie la răspândirea folosirii tehnologiilor, ci şi expunerea la mai multe alegeri în care acestea sunt disponibile [9] .Aşadar, s-au confirmat ambele ipoteze de cercetare de la care a pornit acest articol, sistemul estonian de guvernare electronică dovedindu-se a fi unul sigur şi eficient, fiind implementat relativ facil şi rapid.

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Towards efficient energy systems: Improving hourly load forecasting for smarter management in Albania

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Abstract
Effective energy load prediction enhances the integration of renewable energy sources that supports the demand response and lead to more sustainable and cost-effective energy systems. This study contributes to the development of a smart energy system in forecasting hourly electrical load in Albania. The data taken into consideration fall in a timeline of three years. The main goal is to improve energy efficiency and optimize resource management by developing accurate and data-driven forecasting models. Accurate and reliable load forecasts are essential to optimize energy distribution, reduce operating costs and maintain grid stability, all of which are essential to building a sustainable and efficient energy infrastructure. Traditional time series models, such as ARIMA and SARIMA, have been widely utilized in load forecasting due to their straightforward design and robustness; however, advancements in machine learning now provide new methods capable of capturing complex patterns and long-term dependencies within time series data. This study applies both classical time series and machine learning models, especially the LSTM model, incorporating exogenous variables such as temperature to improve the precision of short-term and medium-term predictions. Model performance is evaluated using accuracy metrics, revealing that machine learning models generally outperform classical time series models, and produce more accurate and reliable results. The findings of the study provide practical insights for energy planners, grid operators, and policymakers in country and region, offering them advanced, precise tools to optimize energy use, enhance grid management, and support efficient resource allocation. The study's key contribution lies in demonstrating the effectiveness of data-driven methods for Albania's energy sector, presenting an application that supports a more resilient and sustainable energy ecosystem.

Keywords: demand, prediction, machine learning, time series, grid stability.

1. Introduction
Efficient energy systems are essential to meet the growing demand of electricity while addressing challenges such as climate change and economic growth. One of the most important tools for effective management of energy systems is load forecasting, which supports the prediction of the amount of electricity needed at specific times. The accuracy of hourly load forecasting is critical for balancing electricity supply and demand, preventing this way power shortages, and reducing unnecessary energy costs. In Albania, where the energy system relies heavily on hydropower, improving load forecasting is especially important. The availability of hydropower can change with weather conditions, making it challenging to plan energy supply ahead of time. By accurately predicting energy demand on an hourly basis, better decisions can be made to ensure a stable and reliable energy system. Over the years, researchers have proposed diverse methodologies to improve short-term load forecasting (STLF) accuracy. In their work [1] proposed a hybrid

forecasting model that integrates a date-framework strategy with improved feature selection techniques. The model combines statistical and machine learning methods to enhance forecasting precision by effectively capturing the complexities of energy consumption patterns. The hybrid model includes Extreme Learning Machine a single hidden layer feedforward neural network (SLFN) model; GABICS (Genetic Algorithm Binary Improved Cuckoo Search), a hybrid meta-heuristic model that combines the Genetic Algorithm (GA) and the Improved Cuckoo Search Algorithm; DFS (Date Framework Strategy), a strategy for selecting the necessary features. This approach addresses the issue of time information loss in the electricity load time series. Whereas [2] demonstrated the superiority of deep learning models, particularly Long Short-Term Memory (LSTM) networks, for short-term load prediction, showcasing their ability to learn temporal dependencies within load data and adapt to non-linear trends. The study compared the LSTM-based model against traditional forecasting techniques, including Autoregressive Integrated Moving Average (ARIMA) and feedforward neural networks, demonstrating superior forecasting performance for LSTM Model. Further innovations were introduced by [3], who emphasized the integration of machine learning algorithms with priority weights to predict energy production in hydropower plants, demonstrating their flexibility and applicability across various energy sectors. Moreover, [4] extended this research by comparing machine learning and deep learning techniques for firm-level load forecasting, underscoring the versatility of these models in practical applications for both micro and macro-level energy systems. The exploration of statistical versus deep learning approaches by [5] provided valuable insights into their comparative performance in energy load prediction, revealing the strengths and weaknesses of each method in diverse forecasting scenarios. The authors analyzed daily load data and performed different statistical and machine learning models which were evaluated on error metrics for both in sample and out of sample dataset. NNAR (Neural Network AutoRegression) outperformed statistical models for in sample dataset but STL (Seasonal and Trend decomposition using Loess) with ARIMA errors performed better for out of sample dataset. In their work [6] further enriched the field with the introduction of constructive neural network approaches, delivering a novel architecture for efficient and adaptive STLF. The constructive neural network model demonstrated superior accuracy compared to traditional forecasting methods such as backpropagation neural networks (BPNN) and ARIMA. Recent studies have placed a strong emphasis on hybrid modeling techniques to address the increasing complexity of energy systems. [7] reported that combination of LSTM and Prophet with time-series decomposition to manage intricate energy patterns, effectively improved forecasting accuracy for dynamic systems. Prophet was used to preserve seasonality information of time series, while stacked bidirectional LSTM model was used for a deseasonalized version of the data. The authors evaluated the hybrid model for monthly energy consumption data for seven countries and compared the model with single Prophet and single stacked bidirectional LSTM, concluding better results with the hybrid model. Similarly, [8] developed a hybrid ARIMAX-GARCH model for electricity consumption forecasting, showcasing the robustness of blending statistical and deep learning methodologies to handle volatility and seasonality. Meanwhile, the authors in [9] underscored the critical need to address climate change impacts on renewable energy production, especially in regions like the Mediterranean that are highly vulnerable to climatic shifts. Statistical and data-driven methods were employed to assess the

relationship between climate variables and energy production. By providing insights into the relationships between climate variables and renewable energy outputs, the article emphasizes the importance of adaptive strategies for ensuring sustainable energy production in the face of climate change. The study [10] examines Albania's electricity demand patterns and their relationship with temperature variations. Understanding the elasticity of electricity demand relative to temperature can inform better demand forecasting and infrastructure planning, ensuring a more resilient energy system. Part of the data used in this study is sourced from this paper. Multi-resolution approaches, such as [11]'s work on daily peak load forecasting, have refined prediction accuracy for specific energy use cases by utilizing granular data analysis. Findings from [12] further expanded these advancements by using hybrid classical and machine learning algorithms for electricity demand forecasting in emerging markets. The article studies energy consumption forecasting using a hybrid model that incorporates a long-term annual trend estimated through regression analysis, a medium-term component involving temperature that combines the ARIMA model and Long Short-Term Memory (LSTM) networks. The short-term component is used to model hourly seasonality. The main advantage of the model lies in its ability to describe the underlying structure and relationships between variables through classical statistical models, thereby enabling a deeper understanding of the influencing factors. Concurrently, [13] developed cooperative ensemble learning with explainable AI techniques, enabling more reliable and interpretable forecasting models suitable for complex energy systems.

Building on these foundational works, this study aims to explore and enhance hourly load forecasting in Albania. The research seeks to address unique challenges in the Albanian energy market, employing an interplay of statistical, machine learning, and deep learning methodologies to achieve better forecasting accuracy. By focusing on the application of these advanced techniques, this work contributes to the broader goal of improving energy system efficiency and sustainability in emerging markets, establishing this way foundations for smarter energy management practices.

The paper's theoretical notions are presented in Section 2. The Seasonal Auto Regressive Integrated Moving Average approach is briefly described, followed by Long-Short Term Memory model. Implementation of these models in hourly load data and temperature in a timeline of three years is described in section 3, together with data analysis and model performance. Conclusions are presented in section 4.

1.1. Data

In our study we use hourly time series data of energy load and temperature for a period of three years (2017-2019). The dataset, taken from [10], includes 1095 days and 26280 hours with no missing values over the interval period. The time is expressed as an integer, whose values range from 0 to 23. Hourly energy load (consumption) is measured in MWh. Temperature is measued in Celsius degree. Hourly data has several key characteristics that make it valuable yet challenging for analysis and forecasting. This high-frequency data, is capturing changes within short time intervals, which allows for detailed insights into patterns and trends over a 24 hour period of time. Hourly load data often exhibits clear daily and weekly seasonality, with peaks during specific hours of the day and variations

across weekdays and weekends. Similarly, hourly temperature data is critical as it strongly influences electricity demand, particularly for heating and cooling purposes. Temperature changes can lead to sudden spikes or drops in energy usage, introducing additional complexity to the forecasting process.

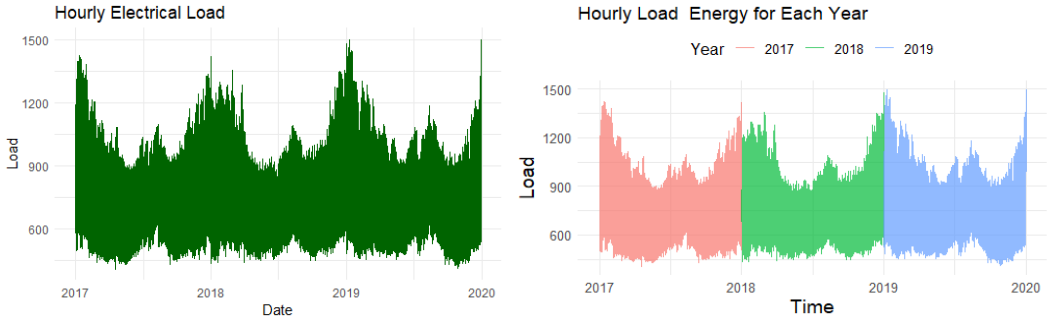

Fig. 1. (a) Hourly Energy Load (MWh); (b) Hourly load for each year
Source: Authors' own work

Fig.1(a) shows the hourly energy load data spanning the years 2017-2019, capturing the dynamic fluctuations in energy consumption over time. Given the hourly nature of the data, the time series shows multi-seasonal patters, influenced by both daily and yearly variations. A detailed analysis of each year in Fig.1(b) shows similar trends patterns for each year. Due to increased demand for heating as temperatures drop during the winter months we observe an increase in the energy load levels. This pattern is followed by a noticeable decline in energy consumption during the spring season, as milder weather reduces the need for heating or cooling. As summer approaches, the energy load begins to rise again, driven by increased cooling demands, reflecting the Mediterranean region's high temperatures, which can often be extreme during this period. Finally, during autumn months, energy load levels decline once more, reflecting reduced demand for temperature regulation. The interplay of heating needs in winter and cooling demands in summer creates a consistent yet distinct seasonal cycle that varies slightly from year to year depending on specific climatic conditions.

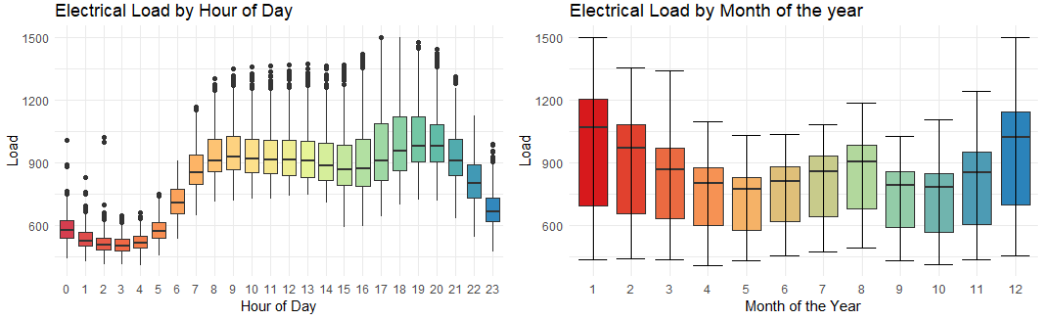

Fig. 2. (a) Average electrical load by hour of the day; (b) Average electrical load by month of the year
Source: Authors' own work

Boxplots in Fig.2(a) represent the average energy consumption over a 24-hour period and reveal distinct patterns in daily energy usage. The energy consumption starts to rise during morning hours when people and businesses start their activity. The highest levels of energy consumption occurs during the late afternoon and early evening hours, specifically between 5:00 PM and 8:00 PM, a time often associated with peak household activity. In contrast, energy consumption is significantly lower during nighttime hours, when non-essential activities are minimized. This pattern is largely influenced by daily routines and lifestyle habits. Such insights into hourly energy consumption patterns are crucial for grid management and demand forecasting, enabling energy providers to better align supply with peak demand periods and implement energy-saving measures during off-peak hours. Electricity consumption by months of the year in Fig.2(b) shows clear seasonal patterns, peaking during the winter months of December, January, and February due to increased heating needs. A secondary rise occurs in August, driven by cooling demands during the summer heat, though it remains lower than winter levels. These trends underscore the strong influence of temperature and seasonal activities on energy usage, highlighting the importance of resource planning to meet varying demand.

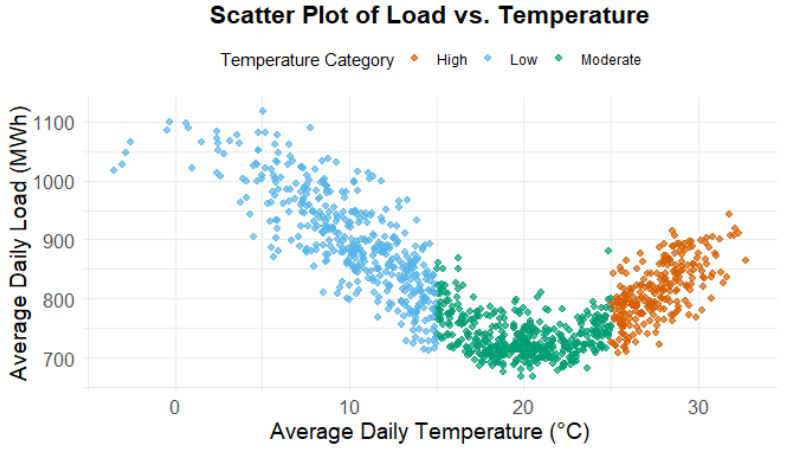

Fig. 3. Scatter plot of average daily load and temperature categorized by temperature
Source: Authors' own work

The scatter plot depicts the relationship between average daily temperature (°C) and average daily energy load (MWh), categorized into three temperature ranges: High (temperature higher than 25°C), Moderate (temperature between 10-25°C), and Low (temperature lower than 10°C). The plot demonstrates a distinct non-linear trend: at low temperatures (blue points), energy load is high, reflecting increased heating demands. As temperatures rise into the moderate range (green points), energy load decreases, indicating reduced heating needs and a more stable demand. This is the time when energy is used for basic activities, such as lighting, cooking, appliance usage etc. At high temperatures (orange points), the load increases again due to cooling requirements during hot weather. This pattern highlights the dual nature of temperature's impact on energy consumption, with peaks observed during both cold and hot periods due to heating and cooling demands, respectively. The scatter plot highlights the importance of understanding the seasonal and

temperature-driven patterns for effective energy planning, load forecasting, and optimizing resource allocation in energy systems.

2. Methodology

The methodology employed in this study integrates both classical statistical modeling and advanced deep learning techniques to forecast energy load. Specifically, we utilize the Seasonal Autoregressive Integrated Moving Average (SARIMA) model, a widely used statistical approach known for capturing seasonality and trend in time series data, alongside the Long Short-Term Memory (LSTM) model, a deep learning framework particularly adept at handling complex temporal dependencies and non-linear patterns. Temperature is used as external variable in both models.

2.1. Data preprocessing

The dataset was thoroughly checked and confirmed to have no missing values, ensuring data integrity for analysis. Prior to model fitting, the data were scaled to normalize features and improve model performance. Since we have a sufficiently large dataset, the best approach for selecting and evaluating models is to divide the dataset into three parts [14]. The dataset was organized into training (80% of data), validation (10% of data) and testing (10% of data) sets, with the training set used for model development and the validation and test sets reserved for evaluating model accuracy. This preprocessing ensured a robust and reliable framework for forecasting. The data were processed in R using packages: *forecast* [15, 16], *keras* [17] and *tensorflow* [18].

2.2. SARIMA model

The Seasonal Autoregressive Integrated Moving Average (SARIMA) model is an extension of the ARIMA model, designed to handle time series data with seasonal patterns [19, 20, 21, 22]. SARIMA incorporates both non-seasonal and seasonal components, making it particularly effective for datasets that exhibit recurring patterns at regular intervals. The model is defined by a set of parameters: (p,d,q) for the non-seasonal part and (P,D,Q,s) for the seasonal component, where p and P represent the order of the autoregressive terms, d and D denote the degree of differencing to achieve stationarity, q and Q specify the order of the moving average terms, and s is the seasonal period. The model can be written as:

$$(1 - \phi_1 L)(1 - \Phi_1 L^s)(1 - L)(1 - L^s)y_t = (1 - \theta_1 L)(1 - \Theta_1 L^s)\varepsilon_t \quad (1)$$

Where:

y_t *- observed time series at time t*
L - backshift operator, representing the lag operator
ϕ_1 *- non-seasonal autoregressive coefficient*
Φ_1 *- seasonal autoregressive coefficient*
θ_1 *- non-seasonal moving average coefficient*
Θ_1 *- seasonal moving average coefficient*
s - seasonal period
ε_t *- white noise error term at time t*

2.3. LSTM model

Long Short-Term Memory (LSTM) introduced by Hochreiter and Schmidhuber, 1997 [23] is a type of recurrent neural network (RNN) specifically designed to handle sequential data and learn long-term dependencies, making it particularly effective for time series forecasting. Unlike traditional RNNs, which struggle with the vanishing and exploding gradient problems, LSTM [24, 25] introduces a unique architecture that includes memory cells and three gates: input, forget, and output gates. These gates regulate the flow of information through the network, enabling it to selectively remember or forget information over extended sequences. A unit of the model consists of a cell, where three gates control the flow of information within the cell. The three gates are: an input gate i_t, an output gate o_t, and a forget gate f_t. The LSTM model connects these cells together, with each cell within the LSTM serving as a memory module.

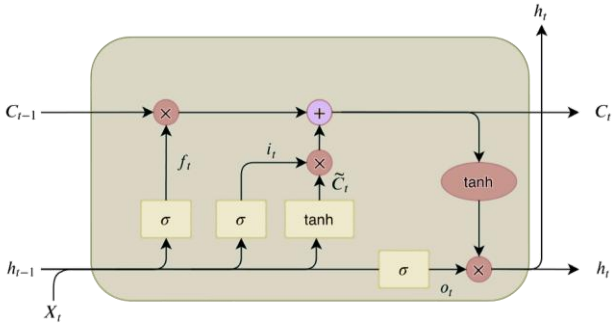

Fig. 4. Long-Short Term Memory architecture
Source: Adapted from [7]

The forget gate instructs the cell on which information to "forget" from its internal state. The input gate tells the cell which new information should be stored in its internal state. The output gate provides the cell's output. All three gates input, output, and forget gates use the sigmoid function, while the hyperbolic tangent function is employed to assess the relevance of the input values within the cell's internal state. The model can be written as:

$$f_t = \sigma\left(\omega_f \cdot [h_{t-1}, X_t] + b_f\right) \quad (2)$$

$$i_t = \sigma(\omega_i \cdot [h_{t-1}, X_t] + b_i) \quad (3)$$

$$o_t = \sigma(\omega_o \cdot [h_{t-1}, X_t] + b_o) \quad (4)$$

$$\tilde{C}_t = tanh(\omega_C \cdot [h_{t-1}, X_t] + b_C) \quad (5)$$

Where:

$\omega_f, \omega_i, \omega_o, \omega_C$ *- weight matrices*
b_f, b_i, b_o, b_C *- biases*
h_{t-1} *- previous hidden state*
X_t *- new input data*
$\tilde{C}_t$*- internal cell state*

The cell state, C_t, is computed as:

$$C_t = i_t \cdot \tilde{C}_t + f_t \cdot C_{t-1} \quad (6)$$

The final output from the cell, h_t, is filtered with the cell state as:

$$h_t = o_t \times \tanh(C_t) \quad (7)$$

2.4. Evaluation metrics

Evaluation metrics are critical for assessing the performance of forecasting models, ensuring their accuracy and reliability. Common metrics used in time series forecasting models include Mean Absolute Error (MAE), which measures the average magnitude of errors; Root Mean Squared Error (RMSE), which emphasizes larger errors by squaring the differences; and Mean Absolute Percentage Error (MAPE), which expresses errors as a percentage of the actual values. These metrics provide insights into a model's precision, consistency, and robustness, enabling comparison and selection of the most suitable approach for forecasting. Mathematically they are expressed as:

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|x_i - y_i| \text{ (mean absolute error)} \quad (8)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - y_i)^2} \text{ (root mean squared error)} \quad (9)$$

$$MAPE = \left(\frac{1}{n}\sum_{i=1}^{n}\frac{|x_i - y_i|}{|y_i|}\right) \cdot 100\% \text{ (mean absolute percentage error)} \quad (10)$$

$$MASE = \frac{MAE}{MAE_{in-sample,naive}} \text{ (mean absolute scaled error)} \quad (11)$$

$$relMAE = \frac{1}{T}\sum_{i=1}^{T}|f(x_i) - f(y_i)| \text{ (relative mean absolute error)} \quad (12)$$

Where:

x_i *- real values*

y_i *- predicted values*

$f(\cdot)$ *- some function that transforms both the predicted and observed values.*

Authors [26] in their study introduce *MASE* as a scale-independent that avoids challenges associated with zero demand values making it particularly suitable for intermittent demand data. While [27] at their study presents *relMAE* as a valuable metrics used for point prediction evaluation, which facilitates comparisons of similar modeling techniques across different time series.

3. Results and discussions

The LSTM model was trained on the training dataset and validated using a separate validation set, with the following configuration: two input time series (Input TSs = 2) and two output time series (Output TSs = 2). The model comprised 60 hidden LSTM units and employed the Adam solver for optimization. Training was conducted over a maximum of 100 iterations (MaxEpochs = 100) with an initial learning rate of 0.005 and no learning rate schedule applied. The gradient threshold was set to 1 to prevent gradient explosion, and a batch size of 64 was used, with each sequence comprising 24 timesteps to capture daily

seasonality. After the initial training and validation process, the model was refitted using the combined training and validation datasets as input, while the test set was used for final validation. This approach ensured that the model used all available data for training while reserving the test set for an unbiased evaluation of performance. The final model was used to make forecasts over short-term and long-term horizons.

Table 1. Accuracy metrics for LSTM model

Metrics	24-h horizon	48-h horizon	5-days horizon	10-days horizon
RMSE	9.764	10.745	14.244	17.124
MAPE	0.986%	1.089%	1.378%	1.569%
MASE	0.173	0.194	0.252	0.268
MAE	7.784	8.474	10.827	11.968

Source: Authors' own work

Accuracy metrics: RMSE, MAPE, MASE and MAE were used to evaluate the model for different prediction time horizon. We can observe from the Table 1 that the accuracy metrics continue to increase as the forecast horizons increase. Findings from [28], suggest that when values of MAPE are below 10% the model forecasts are highly accurate. Fig. 5 also shows that the prediction values are close to actual test values. Additionally, the LSTM model delivers strong forecasting performance even for medium- term horizons, showcasing its ability to capture both short- and long-term dependencies effectively. This highlights the robustness of LSTM in handling complex temporal patterns in energy load data.

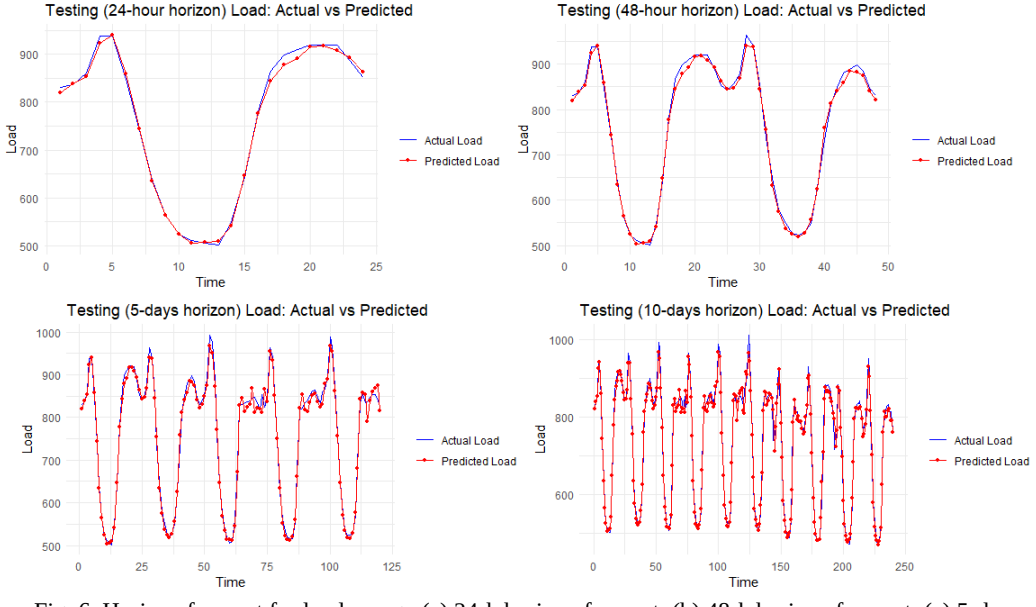

Fig. 6. Horizon forecast for load energy (a) 24-h horizon forecast; (b) 48-h horizon forecast; (c) 5-days horizon forecast; (d) 10-days horizon forecast

Source: Authors' own work

The second model used is SARIMA and SARIMAX over the same horizons and accuracy metrics are evaluated on the test data. The process of modelling is the same as in LSTM. Firstly the model is trained on train dataset and evaluated on validation set. Then we refit the model using train and validation set combined. The results are shown in the Table 2. The table demonstrates that SARIMA(X) provides more accurate results for 5-days horizon forecasts. We have compared the performance metrics of the LSTM model and SARIMA(X).

Table 2. Accuracy metrics for SARIMA and SARIMAX

Model	RMSE	MAPE	MASE	MAE
SARIMA 24h	26.7	2.54%	0.467	20.7
SARIMA 48h	26.3	2.56%	0.468	20.3
SARIMA 5-days	20.9	2.04%	0.369	16.0
SARIMA 10-days	38.1	3.69%	0.639	28.5
SARIMAX 24h	26.3	2.39%	0.438	19.4
SARIMAX 48h	27.0	2.57%	0.472	20.4
SARIMAX 5-days	22.7	2.19%	0.400	17.3
SARIMAX 10-days	43.6	4.55%	0.728	32.5

Source: Authors' own work

Results show that LSTM model performs better in forecasting hourly load data over 24h, 48h, 5-days and 10-days horizons as the error measures are significantly lower compared to SARIMA(X).

4. Conclusions

In this study, two main models were employed to forecast hourly energy load, integrating temperature as an external variable to enhance predictive accuracy. Among the approaches tested, the Long Short-Term Memory (LSTM) model demonstrated superior performance compared to SARIMA(X) over both short-term and medium-term horizons, effectively capturing complex temporal dependencies and non-linear relationships. These results highlight the potential of advanced deep learning methods in addressing the challenges of hourly energy data forecasting. Improved accuracy in load predictions directly contributes to smarter energy management, enabling better resource allocation, reducing operational costs, and supporting the integration of renewable energy sources. By adopting such efficient forecasting techniques, Albania can advance towards a more intelligent and sustainable energy system, aligning with global trends in smart energy management.

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Digital transformation in education: ASEM case study and the integration of modern technologies in the learning process

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Abstract
In the conditions of European integration the development of the Republic of Moldova will have a special connotation, namely - the adjustment of the society to the requirements of a highly digitalized European society. In the article the authors aim to emphasize the importance of integrating information and communication technologies in university education in the Republic of Moldova in order to meet the requirements of a modern society. The main objective is to assess the impact of digitization on the educational process in ASEM. The research conducted in the article is an analysis of the current state of digitization in the Republic of Moldova, with a case study focused on the implementation of the digital teaching-learning-assessment process at ASEM. This approach is based on observing how digital platforms and tools can enhance student autonomy through online collaboration and support teachers in adapting teaching methods to current requirements. The presented results conclude that the digitization of education at ASEM not only improves the academic results, but also contributes to the increase of teachers' competences by diversifying the working methods. The key contribution of the article is to highlight the importance of digital competences for the European integration of Moldova and to demonstrate how ASEM can become a model of digital transformation in education. This is an original approach that underlines the need for sustained efforts in maximizing the use of technology in education, as digitization is considered a central pillar in national development.

Keywords: digitization of education, Information Technologies, learning-teaching-assessment process, university education, SMART education.

1. Introduction

Digital transformation represents a critical process for modernizing and improving the efficiency of various economic and social sectors, thereby contributing to increased competitiveness and enhancing the quality of life for citizens.

The digital transformation of education is a comprehensive process designed to optimize the learning experience and address the demands of an increasingly digitized society. The possibility of digitalizing education emerged with the advent of the Internet, profoundly and permanently impacting the education sector.

Starting in March 2020, the COVID-19 pandemic significantly accelerated the digitization process, forcing educational institutions worldwide to close their doors and rapidly shift to online teaching to ensure continuity in education.

COVID-19 exposed the vulnerabilities of traditional education systems and hastened the adoption of digital technologies in schools and universities. The study “Digital Learning in Higher Education: COVID-19 and Beyond” [1] demonstrates how the pandemic expedited the implementation of educational platforms, with Moodle being used by over 70% of European universities during this period.

This research aims to explore the challenges and opportunities of digital transformation in Moldova's education system, focusing on accelerating the process toward creating a Smart Education system.

The rapid transition to online teaching revealed the weaknesses of traditional educational systems and underscored the need to adapt to new technologies. Despite numerous challenges, including inadequate infrastructure and limited teacher training, online education proved to be a necessary solution for addressing educational needs during the crisis.

The rapid digital transformation, initiated by the need to continue education under difficult circumstances, profoundly impacted Moldova's education system. This process has become a catalyst for modernizing education and is expected to continue and expand in the coming years. In the context of the rapid advancement of information and communication technologies (ICT), educational systems must adapt to meet the demands of a knowledge-based economy and society. Integrating emerging technologies such as artificial intelligence (AI) and augmented reality (AR) promises to transform education into a more interactive and personalized experience.

As digital education becomes a central pillar of modern learning, Moldova is focusing on strengthening and expanding its digital educational infrastructure. The digital transformation of education is not merely a response to global crises but also an opportunity to prepare the younger generation for the challenges of a technology-driven economy and society.

Thus, the digitalization of education in Moldova has become a strategic objective, significantly impacting the future of education and the development of digital competencies in new generations.

This study’s core contribution lies in the detailed analysis of digital transformation in Moldovan education, highlighting strategic steps and the long-term impact of this process. Moldova's educational policies are aligned with European and international frameworks, which makes this analysis relevant for addressing the current challenges and needs of the education system and its beneficiaries.

International strategies for digitalizing education systems, such as Smart -Edu (Romania), have influenced the need for a strategic direction in Moldova’s Education 2030 Strategy [2] and other strategic documents.

In light of the rapid global digital transformations, it is essential for Moldova to develop a coherent strategy for creating a Smart Education system. This study includes a case analysis that examines digital transformations in Moldova's education system, using the digital initiatives implemented at ASEM as a model for establishing a Smart Education system.

Given the rapid pace of educational digitalization, this study clarifies and delineates the fundamental concepts of Smart Education, emphasizing their essence in the context of profound global educational transformations. These concepts are critical for understanding how emerging technologies and innovative approaches contribute to creating more interactive, personalized, and accessible education, thus preparing future generations for the challenges of a digitized society.

2. The concept of "SMART" in education

The concept of "SMART" in education has evolved over time and been interpreted in various ways, reflecting technological and pedagogical developments. Schematically, Smart Education can be illustrated as follows:

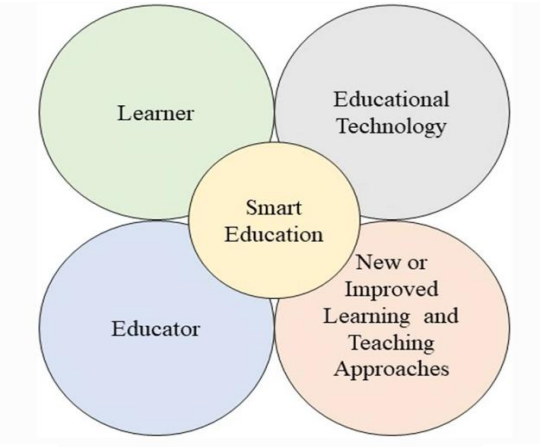

Fig.1. Essential elements of smart education
Source: Demir,2021 [3]

Various researchers have differing opinions regarding the definitions of SMART Education. Before delving deeper, it is essential to clarify the concepts that, in the authors' view, are gaining prominence:

- E-Education refers to the use of electronic media and tools to facilitate learning, including computers, the internet, and digital platforms for delivering education.
- Digital Education encompasses the broader application of digital technologies, including online courses, Learning Management Systems (LMS), and digital tools to enhance educational experiences.
- Smart Education integrates intelligent systems, personalized learning, artificial intelligence, and data analytics to create adaptive learning environments that improve student performance.

These definitions reflect the diversity and evolution of the concept of intelligent education, illustrating how technology and pedagogy converge to create more efficient and accessible learning environments.

Let us focus on the final concept, which encapsulates all the previous ones. To do so, we review the definitions of "SMART" used in education:

Table 1. Concepts and acronyms of SMART education in specialized publications

	The concept and source	Characteristic
1.	**SMART Education as an Acronym for Science, Mathematics, Aerospace, Research, and Technology** Source: Thomas & Carruthers, 2003 [4]	This definition was introduced by Thomas and Carruthers in 2003, focusing on the key academic fields that form the foundation of intelligent education. S.M.A.R.T. was used to describe a curriculum integrating these fields to prepare students for careers in science and technology.
2.	**SMART Education as an acronym in the context of Self-directed, Motivated, Adaptive, Resource-enriched, and Technology-** embedded. Source: Keris, 2011 [5]	This definition was proposed by the Ministry of Education, Science, and Technology (MEST) of South Korea as part of the 2011 Smart Education Advancement Strategy. MEST decomposed the term SMART in the context of intelligent education to emphasize the characteristics of smart education. The acronym SMART was broken into five components to highlight the essential features of intelligent education, focusing on personalized learning methods integrated with technology.
3.	**SMART Education (Situated learning, Mastery learning, Adaptive learning, Reflective learning, and Thinking tools)** ***Source: Meng (2020)*** [6]	Meng (2020) considers that smart pedagogy includes the following key elements: SMART (Situated learning, Mastery learning, Adaptive learning, Reflective learning, and Thinking tools), curriculum design, and teaching strategy. It is evident that smart pedagogy focuses on instruction and learning but is significantly different from education. Smart education emphasizes the support of intelligent technology, as highlighted in the following studies.
	SMART Education as part of the initiative.	
4.	**SMART Education as part of the "Smarter Planet" initiative** **Source:** Palmisano, 2008 [7]	In 2008, Palmisano, CEO and President of IBM, launched the "Smarter Planet" initiative, which also included smart education. It emphasized the importance of utilizing advanced technologies, such as cloud computing, to transform education and make it more accessible and efficient.
5.	**SMART Education in the context of urban communities and schools** **Source**: Rothman, 2007 [8]	Rothman (2007) discussed how districts and communities can create smart education systems in urban schools, emphasizing collaboration and the use of informational resources to enhance the educational experience.
	SMART through ICT technologies.	
6.	**The development and progress of SMART education through ICT technologies.**	In 2009, Jim Rudd and others highlighted the role of cloud computing and other smart technologies in the education of the future in the IBM RedGuide publication. Source: Jim Rudd et al., 2009 [9]

		In 2011, Vlad and his colleagues mentioned the use of notebooks and information technology to build SMART education platforms. This allowed students to better understand electronic components and simple circuits, emphasizing the importance of technology in education. Source: Vlad et al., 2011 [10]
		A definition provided by Zhu and He (2012) [11] is that "the essence of smarter education is to create intelligent environments through the use of smart technologies, so that intelligent pedagogies can be facilitated to provide personalized learning services and enable learners to develop wisdom talents that have a better orientation towards values, improved quality of thinking, and stronger behavioral capacity." In 2016, the authors Zhu and Yu. [12] mentioned another definition of SMART education as "the concept of learning in the digital age." Source: : Zhu et al., 2012-2016 [11, 12]
		According to Bajaj and Sharma (2018), smart education is "about providing personalized learning, anywhere and anytime." Source: Sharma, 2018 [13]
	SMART education according to the OECD	
7.	The main characteristics of smart education highlighted by the OECD include Personalization, Data utilization, Hybrid learning environments, Blockchain for accreditation, and Assistant robots. Source: OECD Digital Education Outlook 2021 [14]	The OECD defines "SMART education" as an approach that leverages advanced technologies, including artificial intelligence, blockchain, and robotics, to transform the way education is delivered and managed. According to the OECD Digital Education Outlook 2021, smart education involves the integration of hybrid human-artificial information systems that support teaching and learning processes, with the aim of enhancing the effectiveness, equity, and cost-efficiency of education systems.

Source: Elaborated by the authors based on the works: Report on National Smart Education Framework [15], *OECD Digital Education Outlook 2021* [14]

Definition proposed by the authors: SMART education is the coherent and efficient use of information and communication technologies (ICT) to facilitate personalized learning and develop advanced competencies in a collaborative environment through innovative and adaptive pedagogical methods. It transforms the educational environment into an intelligent one, promoting critical thinking skills, adaptability, and value orientation.

3. Evolution of smart education: accelerating digital transformation

In recent decades, education has evolved significantly, especially due to the impact of digital technologies. This rapid change has been driven by the need to adapt educational systems to an increasingly digitized world. Thus, the concept of Smart Education has begun to gain ground, representing a profound transformation in the way we learn and teach. Compared to traditional education, Smart Education brings a series of innovations that not only improve the educational process but also make it more accessible and personalized.

It is important to note that the essential difference between traditional education and Smart Education is the way technology is used to support the educational process (see fig. 2).

However, traditional education does not necessarily need to be abandoned; many of its values, such as direct interaction between teachers and students, can be integrated into new

educational models. In fact, a successful educational system should combine the best elements of both approaches, creating a learning environment that leverages both modern technology and traditional human teaching.

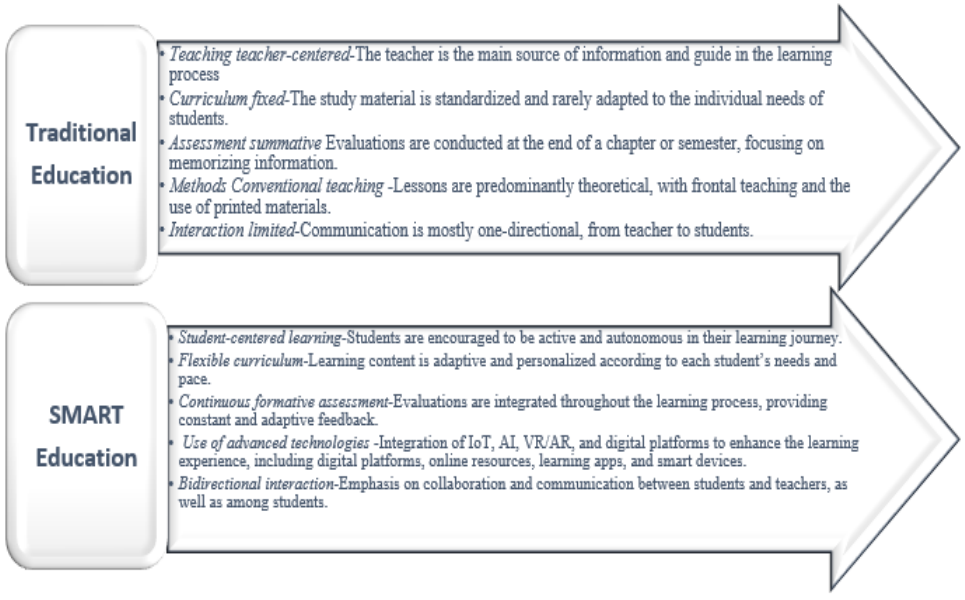

Fig. 2. Characteristics of Traditional and SMART education systems.
Source: Elaborated by the authors based on the works

The digitalization of education offers a more flexible, personalized, and accessible system, capable of more effectively meeting the diverse needs of students. The acceleration of digital transformation has led to the emergence of Smart Education, which enriches personalized learning through the integration of intelligent systems, artificial intelligence, and data analytics, thereby creating adaptive educational environments tailored to each student's performance and learning pace.

Smart Education has gained significant global attention in recent decades, with many educational projects being implemented in recent years. This activity began in 1997 in Malaysia, which first launched a Smart Education project, and later, in 2002, the Smart School Implementation Plan in Malaysia. Seven countries are pioneers in this field of educational research (see fig. 3).

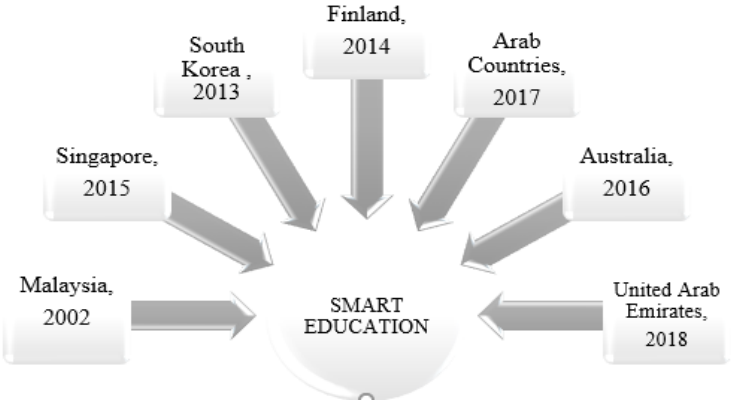

Fig. 3. Country with pioneering initiatives in smart education
Source: Elaborated by the authors based on the works [12]

Although Smart Education brings numerous benefits, it is not without challenges. First, access to technology can represent a significant barrier for less developed regions, where digital infrastructure is not sufficiently well-developed. Furthermore, the effective implementation of new technologies requires a continuous process of teacher training, as educators must quickly adapt to innovative teaching tools and methods. Additionally, the shift to digital learning raises concerns related to data security and privacy protection, essential aspects that must be carefully managed in the context of an increasingly digitalized education system.

To support the growth and development of Smart Education, it is crucial to minimize these risks. In this regard, developing a clear national strategy for the development of Smart Education becomes an urgent necessity. International strategies in the field of educational system digitalization have demonstrated the significant impact of an integrated and coherent vision, emphasizing the importance of a national strategic framework for the digitalization of education.

To build a successful "digitized learning system", national government leaders must adopt a comprehensive approach, structured around three main pillars:

- A renewed focus on transformative teaching and learning, enabled by technology, to foster innovation and adaptability in educational processes.
- Building a robust digital infrastructure that supports accessible and flexible smart education.
- Ensuring forward-looking political and governance initiatives that support the long-term sustainability of educational digitalization.

The framework below outlines the core elements of each supporting point (fig. 4) [15]:

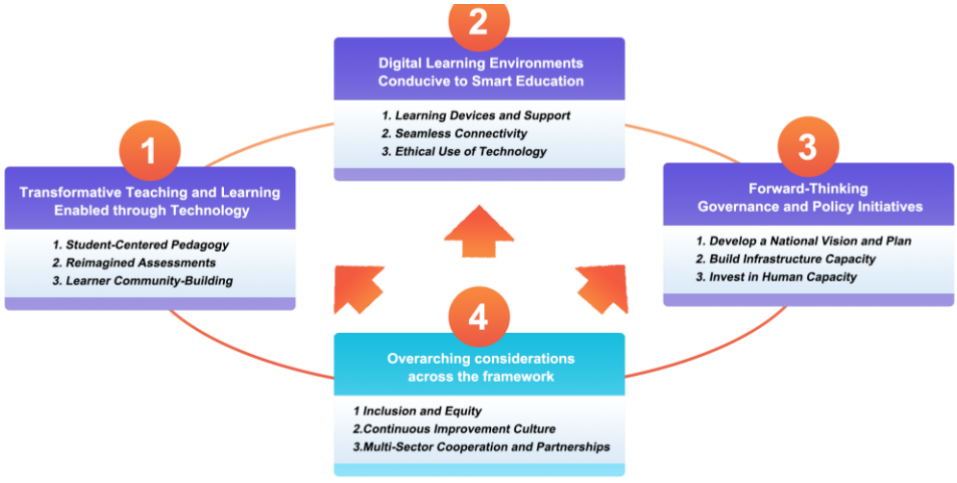

Fig.4. National Smart Education Framework
Source: Report on National Smart Education Framework [15]

These directions will contribute to strengthening an educational system adapted to the needs of the 21st century, one that responds to the challenges and opportunities brought by the digital revolution.

4. Analysis of platforms used at ASEM

The transition towards digitalizing the educational process by adopting educational platforms (Moodle) in most universities in the Republic of Moldova has been an important step towards modernizing education and aligning it with international standards. This shift has allowed for improved access to education, streamlined learning processes, and the creation of a more interactive and collaborative educational environment.

In the paper "Digital Transformation in Higher Education" (Jones et al., 2021) [16], it is argued that digital platforms contribute to increasing the accessibility and flexibility of the educational process. Specifically, Moodle has been recognized for its ability to integrate diverse resources and support collaborative learning.

The implementation of the Moodle system began in 2005, initially used by the faculties of Cybernetics, Statistics and Economic Informatics (CSIE), and Business Administration (BAA). In 2009, ASEM expanded the infrastructure by launching a portal (ASEM VLE) and the widespread use of email accounts (later based on Microsoft 365), aimed at informing users about educational technologies. In 2010, ASEM started designing the Anti-Plagiarism system, which was tested in 2011 for the defense of theses at the CSIE faculty. Since 2012, this system has been used to evaluate the work of all graduates at ASEM. System updates are carried out annually, based on user feedback [17].

As a starting point, the project - module Anti-Plagiarism CROT, the only available at the time, was used [18].
Over the years, the VLE-Moodle platform at ASEM has included several anti-plagiarism systems to ensure academic integrity and originality of student work. These are:

• Sistemantiplagiat.ro - A widely used originality verification service in educational institutions in Romania and the Republic of Moldova. It helps detect plagiarism by comparing documents with a vast database.

• Plagiarism Detector - An efficient tool that analyzes and compares documents with various online sources and databases to detect plagiarism.

• Internally Developed Software - A temporary system without a commercial license, created by the institution's technical team to supplement originality checks. Typically, such systems have limited functionalities compared to commercial ones but are useful for an initial check of documents.

Another important aspect of ASEM's IT infrastructure is the identification and authentication system, first implemented in 2012. This system aims to integrate a Single Sign-On (SSO) concept within ASEM's IT system, facilitating connectivity to the EDUGAIN [17], network, an international federation for academic identity. In 2015, ASEM successfully connected to EDUGAIN, thus enhancing interoperability with other educational and research institutions [19].

The structure of ASEM's Information System (SI), presented by Sclifos C. in the work "Data Integration in the University Information System," [20] is depicted in Fig. 5.

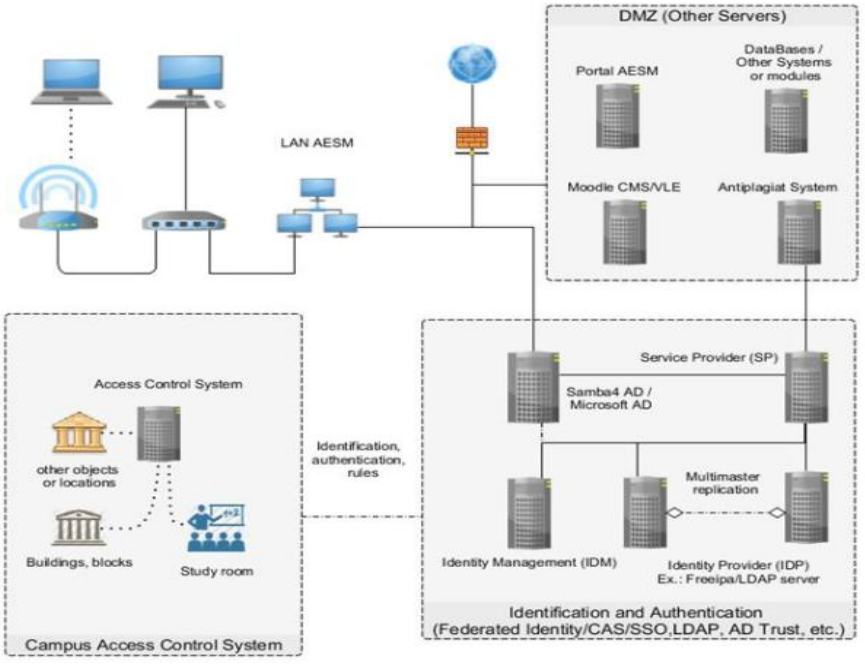

Fig. 5. Model of information systems (IS) used in ASEM
Source: Data Integration in the University Information System [20]

The SI ASEM model was modified at the identification block, expanding the infrastructure through the launch of the ASEM VLE portal (Fig. 6).

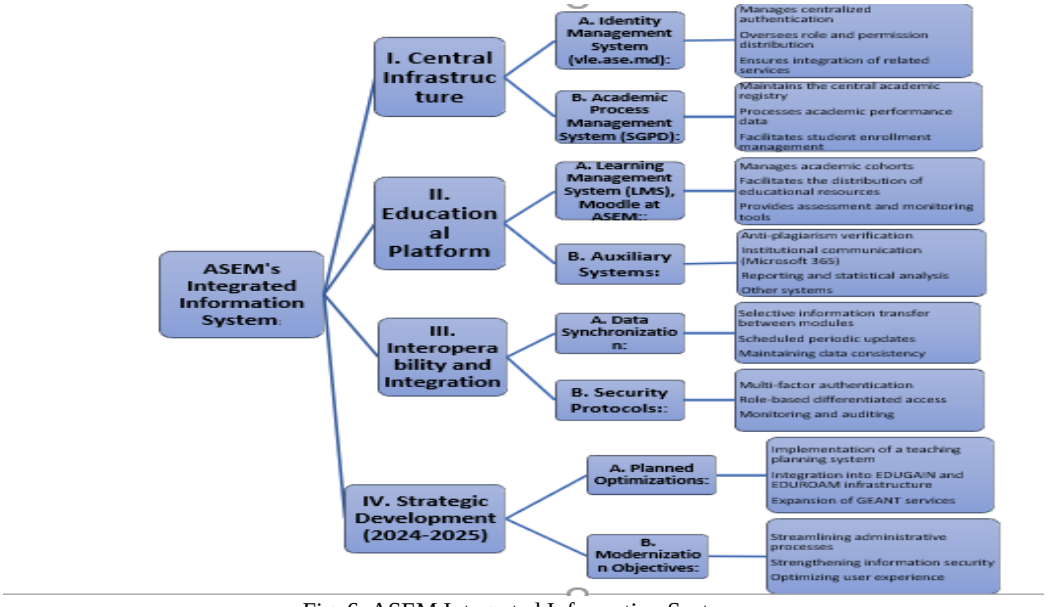

Fig. 6. ASEM Integrated Information System.
Source: Elaborated by authors according to [19]

At ASEM, the digitalization process has been accelerated in recent years through the implementation of the Moodle and VLE.ASEM platforms, leading to the modernization of teaching and administrative processes.

VLE (Virtual Learning Environment) is a term referring to an Information System used to facilitate online or hybrid learning by providing educational resources, learning activities, and an interactive virtual environment for students and teachers.

The structure of a Virtual Learning Environment (VLE) consists of several interconnected components that allow the management and facilitation of the educational process in a virtual environment. While each educational institution can customize a VLE, the basic structure includes several key modules and functionalities that support online learning.

In the context of ASEM, VLE, with its complex modular digital infrastructure, is an integrated platform that includes various tools for learning, communication, and administration of the educational process, designed for the efficient management of the educational process.

Having such a modular architecture allows for easier interoperability of components, while ensuring the functional autonomy of each subsystem. Through the Didactic Process Management System (SGPD), which is access-restricted, all grading-related information is managed.

Another module related to the allocation of class hours is currently in the testing phase. The development of the Document Circulation System (SCD) through the implementation of the 1C software, specialized in automating administrative processes and managing

documents in the allocation of class hours, can bring multiple benefits and improvements within the Academy of Economic Studies of Moldova (ASEM). The connection of this module to Edugain and Eduroam is being modified. The completion of these works is planned for this year, and in 2025 the expansion of services offered through the GEANT [21] project is anticipated.

ASEM and VLE Structure

In the case of ASEM and other institutions utilizing VLE, the structure includes the following components [22, 19]:

1. User Interface (UI)
   - Homepage: Here, users (students and teachers) log into the platform and access various educational resources and activities.
   - User Profile: Each user (student, teacher, administrator) has a profile that includes personal information, activities, and educational progress.
2. Course Modules
   - Online Courses: Courses are organized into modules or sections, each representing a learning unit. Each course can include resources such as PDF files, presentations, video lessons, documents, and external links.
   - Units and Lessons: Each course can be divided into units or lessons containing specific study topics and activities.
3. Interactive Learning Features
   - Forums and Discussions: Students and teachers can communicate through forums to discuss course topics, ask questions, or share ideas.
   - Work Groups: Students can work in groups to collaborate on projects or tasks, with access to group resources and the ability to discuss.
   - Interactive Activities: These can include tests, quizzes, educational games, online assessments, and feedback sessions.
4. Assessment Tools
   - Tests and Quizzes: Teachers can create tests with multiple-choice, true/false, or open-ended questions, which can be graded automatically or manually.
   - Evaluations and Feedback: Students receive evaluations for their activities and feedback from teachers, usually integrated into a grading system.
5. Course and Account Management
   - Course Administration: Teachers can create, edit, and manage courses. They can organize educational content, manage participants, and set access rules.
   - User Management: Platform administrators can create accounts for students and teachers, manage their permissions, and monitor platform activity.
6. Educational Resources
   - Libraries and Study Materials: VLE can integrate additional educational resources, such as e-books, academic articles, and multimedia resources, accessible to students.
   - Shared Documents: Students can upload files, projects, and assignments, and teachers can distribute educational documents and materials.
7. Progress Tracking
   - Activity Logs: Teachers and administrators can track student progress through detailed activity reports (time spent on the platform, activities completed, etc.).

- Activity Planning: Calendars and task lists help plan lessons and academic activities.

8. Integration with Other Systems
   - External System Integration: VLE can be connected with other educational platforms or management systems, such as the "e-management" system, to create a more integrated and unified educational experience.
   - Moodle: For example, if VLE includes Moodle, it can be used to organize and distribute learning materials, create online exams, and monitor student progress.

9. Communication Tools
   - Internal Messaging: Messaging system for direct communication between students, teachers, and administrators.
   - Meetings and Video Conferencing: Integration with video conferencing platforms (e.g., Zoom, Teams) for real-time online classes.

10. Support and Training
   - Technical Support: VLE provides technical support to users for access or functionality issues.
   - Tutorials and Guides: Educational resources for students and teachers, helping them learn how to use the platform and maximize its functionalities.

In conclusion, the structure of VLE-Moodle at ASEM is designed to support online learning by integrating various functionalities. These contribute to creating a complex virtual educational environment that supports both autonomous and collaborative learning. The digital transformation of education at ASEM is a relevant example of adapting to modern requirements for creating a virtual environment. Although the process has been successfully implemented, there are areas that require ongoing improvements.

5. Conclusions

Digital transformation is a sure path towards creating a complex and innovative virtual educational environment, paving the way for a more secure and adaptable future. By integrating modern technologies, higher education institutions like ASEM can provide students with top-notch educational resources and experiences, efficiently preparing them for global challenges and enabling them to excel in their future careers. The ASEM case study demonstrates how integrating modern technologies into the learning process can support both autonomous and collaborative learning. This approach not only improves the quality of education but also increases the competitiveness of higher education institutions, preparing students for the challenges of an increasingly digitalized society. Digitalization in education brings numerous benefits, including increased accessibility, reduced administrative time, and greater learning flexibility. However, this process also faces challenges such as unequal access to the internet, the need for continuous teacher training, and the overburdening of IT resources. To maximize benefits and overcome obstacles, it is recommended to continue investing in IT infrastructure, organize periodic training courses for teachers, and develop strategies to reduce the digital divide among students. These measures will contribute to creating a modern, inclusive, and efficient educational environment, ready to meet the needs of an evolving society.

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Integrating intelligence: The Importance of LLMs and AI agents in strengthening cybersecurity ecosystems

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Abstract
Objectives: This research paper explores the significance of integrating large language models (LLMs) and AI agents into existing cybersecurity ecosystems. As cyber threats become more sophisticated, traditional security measures often fall short. This study highlights the need for intelligent integration to enhance the efficacy of cybersecurity tools and improve threat mitigation strategies. Prior Work: The paper builds on foundational concepts in cybersecurity and artificial intelligence. It synthesizes research on LLM applications and AI agents in security contexts while addressing the limitations of current tools. By examining the intersection of traditional practices and advanced technologies, this review situates the discussion within the broader landscape of ongoing research in the field. Approach: Through thematic analysis and synthesis of literature from multiple sources, the study identifies key themes related to the integration of LLMs and AI agents in cybersecurity. It explores relationships between these themes, providing insights into how they collectively enhance security measures and adaptive response capabilities. The review also formulates a central research question regarding the specific impacts of this integration. Results/Findings: The Intelligent Cybersecurity Synergy Framework (ICSF) is introduced as a result. This framework outlines essential components and processes for effectively integrating LLMs and AI agents into existing cybersecurity tools, thereby enhancing their functionality and responsiveness. Implications: The findings are innovative and can assist researchers and practitioners in understanding the benefits of AI integration in cybersecurity ecosystems. This framework can inform future implications for adopting AI-driven solutions, ultimately improving security postures against evolving threats. Value: This paper contributes a comprehensive synthesis of literature on LLM and AI agent integration in cybersecurity, offering a unique perspective on their transformative potential in strengthening cybersecurity ecosystems.

Keywords: Cybersecurity integrations, Proactive defense, Large Language Models, Artificial Intelligence Agents.

1. Introduction

1.1.Key terms

Large Language Models (LLMs): Large Language Models are sophisticated AI systems that are trained to process and generate human-like text. Utilizing extensive datasets, these models employ deep learning techniques, especially transformer architectures, to grasp context and semantic meaning. This enables them to perform a variety of language-related tasks effectively, including but not limited to text generation, summarization, and sentiment analysis. Prominent examples include OpenAI's GPT series and Google's BERT, which have shown exceptional performance across numerous applications in natural language processing [1].

AI agents: AI agents refer to autonomous entities that harness artificial intelligence methodologies to accomplish specific functions with minimal human oversight. These agents operate within set guidelines and possess the ability to learn from their experiences in a given environment. Their application in cybersecurity is particularly valuable, as they can analyze patterns, detect anomalies, and react to threats instantly, thereby bolstering an organization's security framework [2].

Ecosystem integration: This term denotes the seamless amalgamation of various technologies, tools, and processes to function cohesively within a broader system. In the realm of cybersecurity, effective ecosystem integration means different security tools, platforms, and AI capabilities work together, enhancing the organization's overall defense against cyber threats. Such integration fosters improved data sharing, communication, and coordinated responses among the security components [3].

Native cloud: Native cloud describes applications and services specifically architected for deployment in cloud environments. These solutions capitalize on principles like microservices and containerization, allowing for enhanced scalability, flexibility, and robustness. In cybersecurity, cloud-native solutions can swiftly adjust to emerging threats, enabling organizations to deploy and manage security measures with greater efficiency [4].

Cybersecurity ecosystem integrations: This concept involves the consolidation of diverse cybersecurity technologies, processes, and personnel within an organization. A well-integrated cybersecurity ecosystem empowers organizations to respond more effectively to threats by ensuring that all components function in harmony, facilitating data exchange and coordinated defensive measures [5].

1.2. Importance

The integration of LLMs and AI agents into cybersecurity ecosystems is crucial for several reasons. As cyber threats continue to evolve in complexity and sophistication, traditional security measures often prove inadequate in addressing the challenges posed by advanced persistent threats, zero-day vulnerabilities, and automated attacks. LLMs and AI agents can enhance existing security tools by providing advanced analytics, automating threat detection, and facilitating proactive response strategies. Moreover, the ability to analyze vast amounts of data in real time empowers organizations to identify patterns and anomalies that may indicate potential security breaches, thereby strengthening their overall defense mechanisms [6].

1.3. Problem

The increasing frequency and sophistication of cyber threats have exposed significant limitations in conventional cybersecurity measures. As noted, traditional approaches often fail to adequately address the dynamic nature of modern threats. This study emphasizes the necessity for intelligent integration of advanced technologies like LLMs and AI agents to improve the efficacy of cybersecurity tools. The challenge lies in understanding the specific components, considerations, and processes involved in successfully incorporating these technologies into existing security frameworks. Addressing this issue is paramount for enhancing threat mitigation strategies and improving overall organizational resilience against cyber threats [7].

1.4. Objective

The primary objective of this research paper is to explore the significance of integrating LLMs and AI agents into existing cybersecurity ecosystems. By identifying the critical components and processes required for effective integration, this study aims to develop the Intelligent Cybersecurity Synergy Framework (ICSF). This framework will serve as a

guiding structure for organizations seeking to leverage the capabilities of LLMs and AI agents to enhance their cybersecurity efforts.

1.5. Primary research question

To guide the exploration of the integration of LLMs and AI agents into cybersecurity tools, it is essential to formulate specific inquiries that will direct the research focus. The primary research question aims to identify the key elements that contribute to successful integration, ensuring that the implementation is both effective and beneficial.

What components, considerations, and processes should be taken into account when integrating LLMs and AI agents into cybersecurity tools?

1.6. Secondary research question

In addition to understanding the components necessary for effective integration, it is important to assess the broader implications of such implementations. The secondary research question seeks to evaluate the impact of integrating LLMs and AI agents on existing cybersecurity tools and practices.

What are the impacts of effectively integrating LLMs and AI agents into existing cybersecurity tools?

2. Literature review

2.1 Applications of Large Language Models (LLMs) in cybersecurity contexts

Recent research has highlighted the significant potential of Large Language Models (LLMs) in enhancing cybersecurity practices. Zhang et al. [8] conducted a comprehensive literature review, analyzing over 180 studies to explore the various applications of LLMs in cybersecurity, including their construction and the challenges faced in this evolving domain. They underscore the ability of LLMs to improve cybersecurity tools by providing actionable insights and guidance.

Caviglione et al. [9] further explore the challenges posed by LLMs, emphasizing the need for effective strategies to identify machine-generated data and combat misinformation. Their work highlights how LLM-capable tools can be leveraged to enhance overall cybersecurity measures.

Moreover, Yamin et al. [10] propose using LLMs to generate dynamic cybersecurity exercise scenarios. By simulating various cyber threats, these scenarios enhance training effectiveness, showcasing the generative capabilities of LLMs in practical applications. Similarly, Laney [11] demonstrates the successful application of LLMs in automating network penetration testing, achieving significant performance improvements.

Keltek and Li [12] introduce LSAST, which combines LLMs with static application security testing to enhance vulnerability detection, improving accuracy and uncovering overlooked vulnerabilities while maintaining data privacy. This integration showcases how LLMs can be instrumental in augmenting existing security frameworks.

2.2. AI agents in cybersecurity contexts

The integration of AI agents in cybersecurity is another area of growing research. Quinn and Thompson [13] applied Google Gemini's AI to develop cybersecurity policies against spear phishing attacks, illustrating the efficacy of AI integration in improving detection and response strategies.

Furthermore, the role of AI agents in active cyber defense has been discussed by Heinl [14], who emphasizes their potential to address evolving threats. However, he also raises concerns about the legal and ethical implications of deploying fully autonomous agents, suggesting that further research is essential in this area.

Panichella [15] highlights the vulnerabilities introduced by LLMs through code suggestions, emphasizing the need for end-user education and training to mitigate potential risks associated with AI agents. Additionally, Valencia [16] introduces ReaperAI, an autonomous AI agent for offensive cybersecurity that identifies and exploits vulnerabilities, but also notes the ethical challenges that accompany its deployment.

Happe et al. [17] assess the effectiveness of LLMs in penetration testing scenarios, revealing how automated tools can exploit a significant percentage of vulnerabilities while also discussing limitations that arise in practical applications. Their findings underscore the necessity for critical evaluation when implementing LLMs in security operations.

Abaimov and Martellini [18] discuss the vulnerabilities of AI in cybersecurity, emphasizing the need for caution in the deployment of machine learning agents, as misuse can lead to significant security challenges.

2.3. Limitations of LLMs and AI agents when integrated with cybersecurity tools

Despite the advancements in cybersecurity technology, the integration of LLMs and AI agents into current tools presents notable limitations. Buesser [19] addresses the risk of private information leakage inherent in LLMs, emphasizing their capability to memorize sensitive training data, which can be exploited by adversaries. Similarly, Gallagher et al. [20] discuss how LLMs can inadvertently enhance phishing and social engineering threats by generating convincing content, thereby necessitating stronger defenses.

Vogelsang [21] also highlights vulnerabilities related to prompt injection attacks, which can disrupt execution flows within LLMs, posing significant cybersecurity risks. To mitigate these issues, he advocates for the development of verification tools for prompts and API calls.

Furthermore, the need for security awareness and education regarding the integration of LLMs and AI agents is emphasized by Panichella [15] , who suggests that user education is crucial for addressing potential risks associated with these technologies.

2.4. Limitations of cybersecurity tools when not integrated with LLMs and AI agents

The absence of LLMs and AI agents in cybersecurity tools can significantly hinder organizations' capabilities to respond effectively to emerging threats. Traditional security

measures often rely on static rules and manual configurations, which are increasingly inadequate against the dynamic nature of modern cyber threats. Singhal [22] asserts that without the adaptive capabilities provided by AI, security systems may fail to detect sophisticated attack patterns, resulting in delayed responses and increased vulnerabilities.

Moreover, the reliance on conventional methods can lead to information overload for cybersecurity teams, as they are tasked with analyzing vast amounts of data without the benefit of AI-driven insights. This limitation can result in critical threats being overlooked or misidentified, as highlighted by Lad [23]**,** who emphasizes that the integration of AI technologies can streamline threat detection and enhance incident response times. Thus, organizations that neglect the integration of LLMs and AI agents may find themselves ill-equipped to navigate the complexities of the cybersecurity landscape.

Additionally, Guerraoui and Gupta [24] examine the necessity of privacy and security in developing LLMs through federated learning, underscoring how traditional tools often lack the flexibility to adapt to privacy concerns effectively.

2.5. Emerging trends in cybersecurity related to LLMs and AI agents

Emerging trends indicate a growing reliance on advanced technologies like LLMs and AI agents in enhancing cybersecurity measures. For instance, Majumdar [25] highlights the importance of establishing robust security standards for LLMs, which is crucial for ensuring their safe deployment in cybersecurity contexts. He emphasizes that adhering to these standards can significantly enhance the reliability and trustworthiness of LLM-based systems.

Bryce et al. [26] explore the dual role of LLMs in cybersecurity, noting their capability to generate both malicious content and defensive measures against cyber threats. This duality illustrates the complex nature of LLM applications in cybersecurity, necessitating ongoing research to fully understand their implications.

Schillaci [27] discusses how advancements in hardware, such as NVIDIA's RTX 4090 graphics cards, have made the on-site deployment of LLMs more accessible. This accessibility allows organizations to leverage LLM capabilities without relying solely on cloud solutions, thus enhancing security measures while addressing data privacy concerns.

3. Method

3.1. Research design

This study employed a qualitative research design to investigate the integration of Large Language Models (LLMs) and AI agents within existing cybersecurity ecosystems. This approach facilitated an exploration of the complexities associated with integrating advanced technologies into traditional security frameworks.

3.2. Literature review and synthesis

The research process began with a comprehensive literature review focused on the applications of LLMs and AI agents in cybersecurity contexts.

3.2.1. Literature search strategy

A systematic search was conducted using multiple academic databases, including IEEE Xplore, Google Scholar, and arXiv. Specific keywords such as "Large Language Models," "AI agents," "cybersecurity," "integration," and "threat mitigation" were utilized to identify relevant publications. This approach aimed to ensure a broad and comprehensive collection of literature pertinent to the study's focus.

3.2.2. Selection criteria

The literature was evaluated based on specific criteria for inclusion, which included relevance to the integration of LLMs and AI agents in cybersecurity, publication in peer-reviewed or reputable academic outlets, and recency. Articles that did not meet these criteria were excluded from further consideration.

3.3. Thematic analysis

Following the literature collection, thematic analysis was employed to systematically identify key themes related to the integration of LLMs and AI agents in cybersecurity.

Familiarization with data: The researcher engaged in a thorough review of the collected literature to gain an understanding of existing research and developments related to the topic.

Coding the literature: Significant features and concepts were extracted from the literature and organized into initial codes. This step involved identifying relevant passages that highlighted important aspects of LLM and AI agent integration.

Identifying themes: The initial codes were grouped into broader themes that encapsulated critical elements of the integration process. This involved examining relationships between codes and synthesizing insights.

Reviewing themes: The identified themes were critically reviewed to ensure they accurately reflected the insights gained from the literature and aligned with the research objectives.

Defining themes: Each theme was articulated clearly to convey its significance in the context of the research questions.

3.4. Framework construction

In addition to the thematic analysis, a framework was proposed to organize the findings related to the integration of LLMs and AI agents. This framework aimed to encapsulate the key themes identified through the analysis and provide a structured approach for understanding the essential components and processes required for effective integration.

4. Results

4.1. Key findings on the integration of LLMs and AI agents in cybersecurity

Through thematic analysis and synthesis of literature from multiple sources, the study identifies key themes related to the integration of Large Language Models (LLMs) and AI

agents in cybersecurity. It explores relationships between these themes, providing insights into how they collectively enhance security measures and adaptive response capabilities. Table 4.1 outlines the identified themes corresponding to the primary research question, Table 4.2 outlines the identified themes corresponding to the secondary research question, showcasing how various articles contribute to understanding the components, considerations, and processes required for the effective integration of LLMs and AI agents into cybersecurity tools. It also details the impacts of this integration, drawing from a diverse range of literature to ensure a holistic view.

Table 4.1.1: Primary Research Question and Identified Themes

Research Question	Identified Themes	How the Article Answers the Research Question	Study Date	Citation
What components, considerations, and processes should be taken into account when integrating LLMs and AI agents into cybersecurity tools?	- Components of Integration - Ethical Considerations - Security Challenges - User Training Needs	Zhang et al. (2024) provide a comprehensive overview of LLM applications and their potential, addressing construction and challenges.	2024	[1].
		Caviglione et al. (2024) explore the security challenges posed by LLMs, providing strategies for integration.	2024	[2]
		Capodieci et al. (2024) highlight the need for a balanced approach in adopting generative AI in cybersecurity practices.	2024	[3]
		Yamin et al. (2024) propose the use of LLMs to create realistic training scenarios, highlighting necessary components for integration.	2024	[4].
		Quinn and Thompson (2024) discuss developing cybersecurity policies to counteract phishing, showing processes necessary for integration.	2024	[5]
		Laney (2024) examines automation in penetration testing using LLMs, suggesting key processes for effective integration.	2024	[6].
		Keltek and Li (2024) discuss how integrating LLMs with static application security testing can enhance vulnerability detection.	2024	[7]
		Panichella (2024) emphasizes user education as a critical consideration for the effective integration of LLMs.	2024	[8]
		Majumdar (2024) emphasizes the importance of adhering to security standards when integrating LLMs into cybersecurity tools.	2024	[9]

Research Question	Identified Themes	How the Article Answers the Research Question	Study Date	Citation
		Guerraoui and Gupta (2024) highlight the necessity of privacy and security in federated learning of LLMs.	2024	[10]

Table 4.1.2: Secondary Research Question and Identified Themes

Research Question	Identified Themes	How the Article Answers the Research Question	Study Date	Citation
What are the impacts of effectively integrating LLMs and AI agents into existing cybersecurity tools?	- Improved Threat Detection - Enhanced Training Simulations - Operational Efficiency - Ethical Considerations	Quinn and Thompson (2024) show that AI integration can significantly improve detection and response strategies against phishing.	2024	[5]
		Happe et al. (2023) assess the effectiveness of LLMs in privilege escalation scenarios, indicating their impact on penetration testing.	2023	[11]
		Singhal (2024) discusses how integrating multiple AI models can enhance the accuracy and speed of threat identification.	2024	[12]
		Bryce et al. (2024) analyze the dual role of LLMs, emphasizing their use in both defense against and the creation of cyber threats.	2024	[13]
		Gallagher et al. (2024) present case studies on phishing and social engineering attacks enabled by LLMs, highlighting their impacts.	2024	[14]
		Schillaci (2024) discusses how advancements in hardware enable on-site deployment of LLMs, improving response capabilities.	2024	[15]
		Holland (2024) examines the potential of LLMs to index the Deep Web, highlighting impacts on data exposure and privacy.	2024	[16]
		Panichella (2024) discusses the necessity of enhancing user security awareness in the context of LLM integration.	2024	[17]
		Vogelsang (2024) addresses prompt injection vulnerabilities, indicating the need for effective security practices post-integration.	2024	[18]

	Kott (2018) emphasizes the importance of intelligent autonomous agents in military cyber defense, relevant to integration strategies.	2018	[19]
	Heinl (2014) discusses policy implications for artificial intelligence in cyber defense, emphasizing ethical considerations.	2014	[20]
	Valencia (2024) discusses operational challenges related to the deployment of AI agents in offensive cybersecurity.	2024	[21]
	Sufi (2023) introduces an intelligent agent-based system to tackle cybercrime, showcasing potential applications for LLM integration.	2023	[22]
	Abaimov and Martellini (2022) discuss the benefits and vulnerabilities of AI in cybersecurity, emphasizing the integration challenges.	2022	[23]
	Lad (2024) highlights the importance of integrating AI to combat emerging threats, relevant for LLM and AI integration processes.	2024	[24]
	Happe, Kaplan, and Cito (2023) evaluate LLMs for privilege escalation, indicating their operational impacts on cybersecurity tools.	2023	[25]
	Gil et al. (2024) investigate the impact of AI on the cybersecurity workforce, revealing the dynamics of adopting LLM technologies.	2024	. [26]
	Majumdar (2024) discusses security standards, focusing on best practices in LLM deployment within cybersecurity tools.	2024	[27]

Table 4.1.3 further elaborates on specific use case topics within the cybersecurity domain, identifying relevant articles that cite the integration of LLMs and AI agents. This table illustrates the tangible impacts of effective integration, highlighting improvements in areas such as phishing detection, training simulations, vulnerability detection, and anomaly detection.

Table 4.1.3: Cybersecurity Use Case Topics

Cybersecurity Use Case Topic	Identified Articles Citing that is Relevant for that Use Case	Impacts of Effectively Integrating LLMs and AI Agents
Phishing Detection	Quinn, T. and Thompson, O. (2024) [5] ; Gallagher et al. (2024) [14]	Integration of LLMs improves detection and response strategies, enabling organizations to combat spear phishing more effectively.
Training Simulations	Yamin, M. M., Hashmi, E., Ullah, M., & Katt, B. (2024) [4]; Laney, S. P. (2024) [6].	Utilizing LLMs for training enhances realism in exercises, allowing personnel to prepare better for actual cyber threats.
Vulnerability Detection	Keltek, M., & Li, Z. (2024) [7]; Happe, A., Kaplan, A., & Cito, J. (2023) [11]; Panichella, S. (2024) [17]	The use of LLMs in static application security testing increases accuracy and identifies vulnerabilities that may have been overlooked.
Cyber Defense Automation	Loevenich, J. F. et al. (2024) [19]; Valencia, L. J. (2024) [21]	The integration of AI agents with LLMs allows for the automation of defense mechanisms, improving response times to cyber threats.
User Education and Awareness	Panichella, S. (2024) [17]; Gallagher et al. (2024) [14]	Effective integration necessitates a focus on user education to ensure awareness of potential threats and the proper use of AI-driven tools.
Ethical and Privacy Concerns	Capodieci, N. et al. (2024) [3]; Buesser, B. (2024) [19]; Guerraoui, R. and Gupta, N. (2024) [10]	Addressing ethical concerns is vital for secure and responsible deployment of LLMs and AI agents in cybersecurity environments.
Emerging Threats	Bryce, C. et al. (2024) [13]; Gallagher et al. (2024) [14]	The integration of LLMs enhances the ability to detect and respond to emerging threats, strengthening overall cybersecurity postures.
On-Site Deployment of AI Systems	Schillaci, Z. (2024) [15]; Majumdar, S. (2024) [9]	On-site deployment of LLMs allows for reduced reliance on cloud solutions, potentially minimizing risks associated with data privacy and leaks.
Data Privacy and Security	Holland, A. (2024) [16]; Guerraoui, R., & Gupta, N. (2024) [10]	Implementing security measures ensures the responsible use of LLMs, protecting sensitive information from unauthorized access and misuse.
Autonomous Agents in Cyber Defense	Kott, A. (2018) [19]; Heinl, C. H. (2014) [20]	The use of intelligent autonomous agents can enhance military cyber defense, providing new strategies for integrating AI in security practices.
Offensive Security Strategies	Valencia, L. J. (2024) [21]; Sufi, F. (2023) [22]	Effective integration of AI in offensive security can improve identification of vulnerabilities, enabling proactive measures against threats.
Anomaly Detection and Response	Singhal, S. (2024) [12]; Happe, A., Kaplan, A., & Cito, J. (2023) [11]; Gil et al. (2024) [26]	Integrating multiple AI models for real-time detection enhances the accuracy and speed of threat identification and response capabilities.
Integration Standards and Best Practices	Majumdar, S. (2024) [27]; Lad, S. (2024) [24]	Establishing standards ensures the reliable and secure use of LLMs in various cybersecurity applications, enhancing overall security posture.

4.2. The Intelligent Cybersecurity Synergy Framework (ICSF)

Based on the findings presented in Tables 4.1.1, 4.1.2 and 4.1.3, this study introduces The Intelligent Cybersecurity Synergy Framework (ICSF). This framework outlines essential components and processes necessary for the effective integration of Large Language Models (LLMs) and AI agents into existing cybersecurity tools, enhancing their functionality and responsiveness.

Framework Components

The ICSF is composed of several key components, each contributing to the seamless integration of LLMs and AI agents in cybersecurity practices:

Integration Architecture: This component focuses on the structural design that enables LLMs and AI agents to interface with existing cybersecurity systems. A robust integration architecture ensures compatibility and facilitates data flow between components.

Data Management Strategies: Effective data management is crucial for utilizing the capabilities of LLMs. This includes data collection, processing, storage, and retrieval protocols that maximize the performance of AI-driven tools while ensuring data privacy and security.

User Training and Awareness: End-user education is vital to the successful adoption of integrated technologies. This component emphasizes the importance of training programs to enhance user skills in leveraging LLMs and AI agents effectively while promoting awareness of potential threats and ethical considerations.

Continuous Monitoring and Adaptation: To remain responsive to evolving cyber threats, continuous monitoring processes must be established. This involves regular assessments of system performance and the ability to adapt integration strategies based on emerging trends and threats.

Ethical and Compliance Considerations: The ICSF incorporates a focus on ethical guidelines and compliance with regulations concerning AI deployment in cybersecurity. This component addresses the need for transparency and accountability in AI practices.

Diagram Visualization

To illustrate the ICSF, the following diagram (Figure 4.2) presents the interrelationships between the various components.

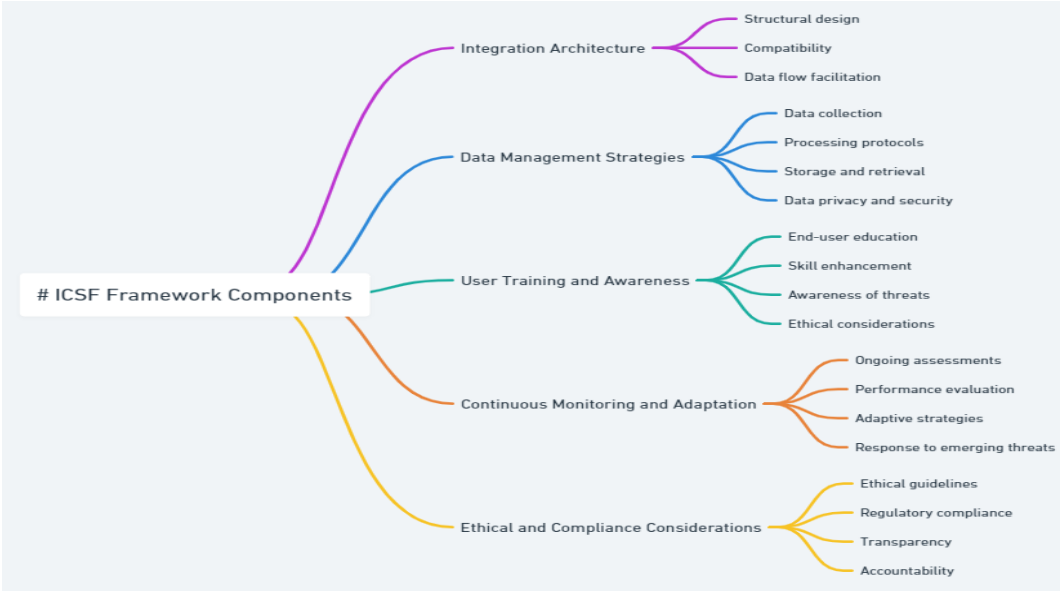

Fig. 4.2. *The Intelligent Cybersecurity Synergy Framework (ICSF)*

5. Discussion

The increasing complexity and sophistication of cyber threats necessitate a shift from traditional security measures to more intelligent integration of technologies. This study highlights the need for such integration to enhance the efficacy of cybersecurity tools and improve threat mitigation strategies. The findings underscore that integrating Large Language Models (LLMs) and AI agents into existing cybersecurity frameworks can significantly elevate defense mechanisms and provide adaptive responses to evolving threats.

5.1. Intelligent Cybersecurity Synergy Framework (ICSF)

The introduction of the Intelligent Cybersecurity Synergy Framework (ICSF) serves as a structured approach to understanding how various components interact to create a robust cybersecurity environment. By emphasizing integration architecture, data management strategies, user training, continuous monitoring, and ethical considerations, the ICSF provides a comprehensive blueprint for organizations looking to adopt LLM and AI technologies effectively. The framework illustrates the dynamic interplay among these components, suggesting that organizations can enhance their threat detection capabilities, streamline responses, and ensure compliance with ethical standards by focusing on these areas.

5.2. Value of the study

This paper contributes a comprehensive synthesis of literature on LLM and AI agent integration in cybersecurity, offering a unique perspective on their transformative potential in strengthening cybersecurity ecosystems. Research indicates that AI technologies are not merely supplementary tools; they represent a fundamental shift in how cybersecurity is approached. For instance, AI-driven tools can analyze vast amounts of data in real-time, enabling proactive rather than reactive security measures [28].

5.3. Connection to cybersecurity cloud adoption

The results of this study are closely tied to the ongoing transition towards cloud adoption in cybersecurity. As organizations migrate to cloud environments, integrating AI and LLM technologies can provide enhanced security features tailored to the unique challenges of cloud computing [29].

5.4. Limitations and future research opportunities

Despite the promising findings, this study is not without limitations. The rapid pace of technological advancement means that the landscape of LLMs and AI in cybersecurity is continually evolving, potentially outdating some conclusions quickly. Additionally, the ethical implications of deploying AI in sensitive security contexts require ongoing scrutiny [30]. Future research opportunities include exploring the long-term effectiveness of integrated LLM and AI systems in real-world cybersecurity scenarios. Additionally, investigating the barriers organizations face in adopting these technologies can provide insights into practical challenges and solutions. Another area for future study is the ethical implications of AI decision-making in cybersecurity contexts, particularly regarding accountability and transparency.

In conclusion, the integration of LLMs and AI agents into cybersecurity tools represents a significant advancement in the field. The ICSF framework provides a valuable guide for organizations aiming to navigate this integration effectively. Continued research in this area will be critical to developing robust, responsive, and ethical cybersecurity solutions.

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IoT-based electrical energy usage monitoring system in a room in a tropical building

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Abstract
Electrical energy in tropical buildings is used for indoor health and comfort (IHC) purposes, namely maintaining room temperature and humidity (according to standards), lighting (according to standards) and operating equipment to support activities in the room in accordance with the function of the room. To be able to monitor the use of AC electrical energy (for thermal comfort), lamps (for lighting) and equipment in the room according to the function of the room, a measuring instrument is needed according to the group of electrical energy users in the room. This measuring instrument is in the form of a wireless power meter on the electrical panel of the electrical network according to the electricity user load (AC, lights and equipment load), so that the measured electrical quantity (electric current (Ampere), electric voltage (Volts), electric power (Watts), Electrical frequency (Hz), power factor (cos phi) can be transmitted via internet or Wifi media to the energy monitoring dashboard. The Dahsboard is equipped with a measured data base from a wireless power meter so that it can be accessed via the building management's mobile phone to monitor the electrical energy usage of the room and its equipment, so that the cost of electrical energy usage in a room and the amount of carbon emissions produced from each kilo can be known. watt hours of electrical energy used in a building. This is because the majority of electrical energy used in Indonesia comes from coal, diesel and LPG (i.e. energy originating from fossil fuels), so that if it is burned it will emit carbon dioxide (CO2) gas which can cause thinning of the ozone layer, resulting in the phenomenon of global warming. By having an electrical energy monitoring system in rooms in tropical buildings, you will be able to monitor the efficiency of electrical energy use in a room, so you can monitor costs for activities in a room and can monitor carbon dioxide (CO2) gas emissions produced from a room due to the use of electrical energy. (use of electrical energy (kWh) produced from burning fossil fuels and the amount of carbon dioxide gas emissions it produces can be calculated). This IoT-based electrical energy monitoring system is very helpful for building management in carrying out efficient use of electrical energy in tropical buildings which has an impact on reducing carbon dioxide (CO2) gas emissions as well as educating building users to care about preventing global warming caused by gas emissions. carbon dioxide (CO2) which is caused by the use of electrical energy from fossil fuels.

Keywords: Efficiency, electricity use, CO2 gas emissions, global warming.

1. Introduction
Electrical energy in tropical buildings is used for Air Conditioning (AC) to maintain thermal comfort in accordance with thermal comfort standards (ASHRAE Standard 55), for lights to maintain lighting intensity in accordance with lighting standards (IES = Illuminating Engineering Society), and for operational supporting equipment indoor activities. The majority of electrical energy in Indonesia comes from coal-fired PLTUs (Steam Power Plants), so every use of electrical energy (kWh) will produce carbon dioxide (CO2) emissions [1]. For this reason, a monitoring system for electrical energy usage per group of indoor users is needed, so that the SEU (Significance Energy Used) per group of indoor electrical energy users can be identified. This energy monitoring uses an electrical panel whose loading has been arranged, namely AC load, light load and equipment load,

this is to make it easier to measure electrical energy by using a digital power meter. The measurement results data will be forwarded by Modbus Gateway to the Web Server Energy Monitoring System for display, stored in a Data Base which can be accessed via mobile phone, so that energy consumption in a room can be monitored from anywhere at any time.

2. Design electrical energy usage monitoring system

The block diagram of the electrical energy usage monitoring system is shown in Figure 1.

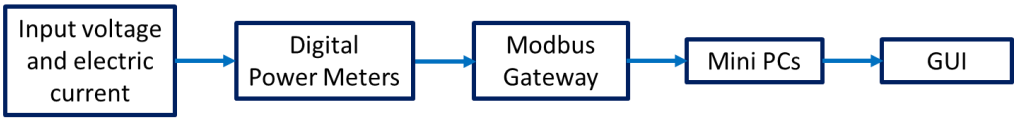


Fig. 1. Diagram blok system monitoring penggunaan energi listrik.
Source: final project Farhan Prasetya Juliantono[1]

There are 3 groups of indoor electrical energy users, namely AC, lights and operational support equipment, so a measuring instrument is needed to measure each load using a digital power meter.

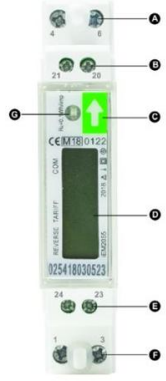


Fig. 2. Power meter digital.
Source: Electric, User Manual Acti 9 iEM 2050, 2021 [2]

Electricity usage in the room can be monitored in real time [3] by using a digital power meter that is integrated with the Modbus communication protocol on the electrical panel, so that the electrical power used by the electrical load can be measured. This is because electrical power is the rate of delivery of electrical energy in an electrical circuit or can also be defined as the electrical energy used in one unit of time. In the SI (International System) the unit of electric power is the watt which states the amount of electric power flowing per unit time (J/s). Electric current flowing in a circuit with electrical resistance causes work. So the electric power formula equation can be written as in equation 1:

$$P = V \times I \quad (1)$$

Where :
P = Daya listrik (W)
V = Tegangan listrik (Volt)
I = Arus listrik (Ampere)

The internet-based energy monitoring system (IoT) is as follows:

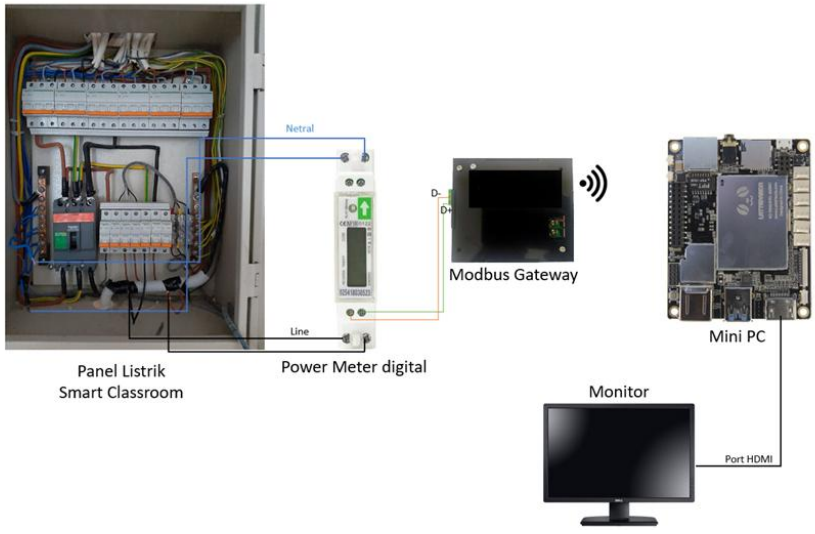


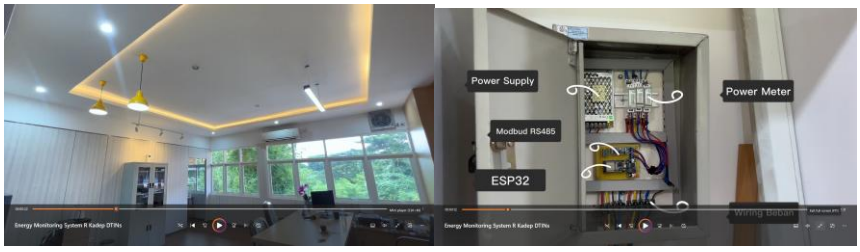
Fig. 3. Wiring diagram system pengukuran besaran listrik.
Source: final project Farhan Prasetya Juliantono [4]

The amount of electricity measured via a digital power meter, namely electric current (amps), electric voltage (volts) and electric power (Watts) can be displayed via a GUI (Graphic User Interface) as shown in Figure 4.

Fig. 4. GUI mendisplaykan besaran listrik yang terukur.
Source: final project Farhan Prasetya Juliantono [1]

3. Analysis and discussion

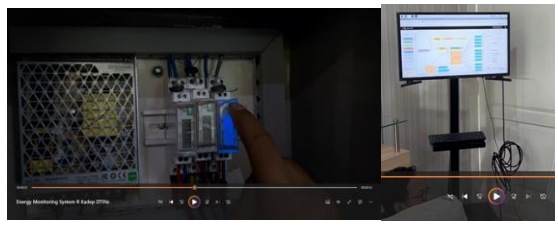
The energy monitoring system is applied in the head room of the Instrumentation Engineering department for thermal comfort (AC), for lighting (lamps) and for equipment to support activities in the room.



a b

Fig. 5. (a) pemakaian energi listrik di ruang; (b) panel listrik monitoring.
Source: photo of the head of the instrumentation engineering department

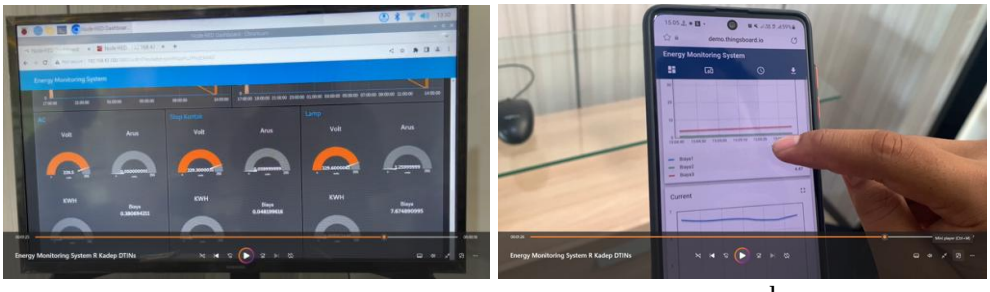
Electrical energy consumption by the electrical load is measured by a wireless power meter (figure 6 (a)) and sent to the energy monitoring system dashboard (figure 6 (b)) by the modbus gateway.



a b

Fig. 6. (a) pengukuran beban listrik; (b) dashboard energy monitoring.
Source: photo of the head of the instrumentation engineering department

The results of measuring electrical energy usage by AC, lights and equipment displayed on the dashboard can then be accessed by mobile phone via the dashboard web server.



a b

Fig. 7. (a) dashboard energy monitoring; (b) display energy monitoring di hand phone.
Source: photo of the head of the instrumentation engineering department

Acknowledgements
Thanks are expressed to the Department of Instrumentation Engineering - Vocational Faculty - Institut Teknologi Sepuluh Nopember (ITS) which has funded the creation of the energy monitoring system and the students who worked on it.

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Formal methods for modeling, analyzing, and dynamically optimizing road traffic

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Abstract
This study builds on existing work in traffic flow modeling, optimization techniques, and Intelligent Transportation Systems (ITS). Research on Lagrange optimization methods and real-time adaptive algorithms has been foundational, as has prior work integrating ITS into urban traffic networks. Related studies in SCRD Journal and SCIC Proceedings highlight the growing importance of dynamic traffic management systems for sustainable urban planning. This research extends these concepts by addressing gaps in real-time adaptability and environmental optimization. The study employs a hybrid methodology that includes simulation-based traffic flow models, algorithmic optimization via Lagrange methods, and real-world data integration from ITS. A combination of case studies and empirical analysis evaluates the efficacy of the proposed models. Simulations incorporate dynamic variables such as traffic density, road network complexity, and environmental metrics to ensure comprehensive assessment. The findings demonstrate significant improvements in traffic flow efficiency, with reductions in congestion levels and CO2 emissions by up to 20% under simulated conditions. The proposed models also enhance adaptive traffic management, showing real-time responsiveness to fluctuations in traffic patterns. This research provides valuable insights for academics, transportation planners, and policymakers. For researchers, it offers a framework for integrating formal methods with ITS technologies. For practitioners, it outlines practical strategies to implement environmentally sustainable traffic solutions. The study's key contribution lies in its integration of formal methods with dynamic traffic optimization, offering a unique and practical approach to addressing urban traffic challenges. The originality of this research ensures its relevance to advancing sustainable and intelligent transportation systems.

1. Introduction
Road traffic congestion is a growing challenge in urban environments, contributing to significant delays, increased emissions, and high economic costs. Traditional traffic management systems struggle to accommodate the dynamic and complex nature of urban traffic, necessitating advanced methodologies that leverage formal frameworks and real-time adaptability. This research addresses these challenges by proposing a novel integration of formal methods with Intelligent Transportation Systems (ITS) to model, analyze, and optimize traffic flows dynamically. Such approaches build upon prior research in data exchange in vehicle-to-vehicle communication systems [1], urban traffic anomaly detection algorithms [2], and network model generation using performance evaluation process algebra [3].

The study explores traffic flow models, including cellular automata, multi-agent systems, and fluid-dynamic simulations, to predict congestion points and enhance traffic flow. To manage constraints such as intersection capacity and signal timing, Lagrange optimization techniques are employed, aiming to minimize delays and improve system efficiency. ITS integration provides real-time data from sensors and predictive algorithms, enabling dynamic traffic parameter adjustments to reduce congestion and emissions.

1.1. Research objectives
This research seeks to achieve the following objectives:
• Develop robust algorithms for optimizing traffic flow and signal timing;

• Design predictive models for traffic density and flow under variable conditions;
• Implement dynamic optimization strategies to mitigate congestion and lower CO2 emissions.

1.2. Methodology

The proposed approach combines formal mathematical methods with ITS technologies. Using simulation-based models and optimization frameworks, traffic patterns are analyzed under varying scenarios. Real-world data from urban traffic systems enhance model accuracy, ensuring practical applicability. For example, techniques reviewed in [4], offer insights into reinforcement learning for traffic flow optimization, while agent-based models discussed in [5] emphasize the potential of adaptive, decentralized control systems.

1.3. Implication

The research offers significant value to academics, transportation planners, and policymakers by providing a scalable and adaptable framework for urban traffic management. It supports the development of sustainable cities through enhanced traffic efficiency and environmental preservation.

This study's originality lies in its application of formal methods to real-time traffic optimization, filling a critical gap in existing methodologies. Its interdisciplinary approach bridges theoretical modeling and practical implementation, offering a valuable contribution to the field of intelligent transportation systems.

2. Illustrations

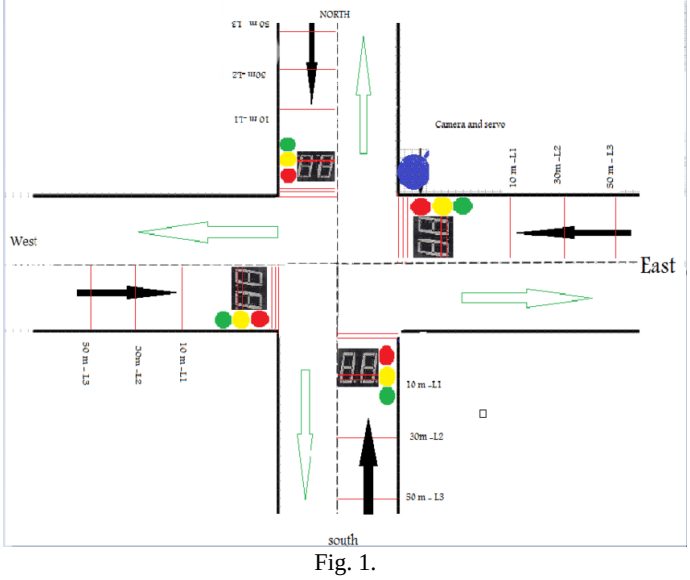

Fig. 1.

Source: Traffic-intersection-with-four-direction-and-single line

3. Equations

$$\frac{\partial \rho}{\partial t} + \frac{\partial (\rho v)}{\partial x} = 0 \quad (1)$$

Where:

- ρ : Traffic density(vehicles/unit length)
- v : Average speed
- t : Time
- x : Position

Traffic Flow Conservation

$$\boldsymbol{q = \rho v}$$

Where: q is the traffic flow(vehicles/unit time)

Lagrange Optimization

For traffic optimization, the Lagrange function combines the objective function and constraints:

$$\mathcal{L}(x, \lambda) = f(x) + \lambda(g(x) - c)$$

Where:

- f(x): Objective function(e.g.,minimize wait time)
- g(x): Constraints(e.g., traffic capacity)
- λ : Lagrange multipliers

Example for intersection optimization:

Objective function: Minimize total waiting time:

$$(x) = \sum_{i=1}^{n} T_i(x)$$

Constraint: Traffic flow must not exceed intersection capacity:

$$g_i(x) = x_i - C_i = 0$$

Solving the system of equations derived from:

$$\frac{\partial L}{\partial x_i} = 0, \frac{\partial L}{\partial \lambda} = 0$$

Karush-Kuhn-Tucker (KKT) Conditions

For inequality constraints:

$$h_j(x) \leq 0, v_j(x) \geq 0, v_j(x) \cdot h_j(x) = 0$$

These allow the inclusion of real-world limitations, such as prioritizing emergency vehicles or public transport.

4. Conclusion

The application of formal methods to road traffic management represents a transformative step toward achieving efficient, sustainable, and safer urban transportation systems. By integrating mathematical modeling, advanced optimization techniques, and real-time data

analytics, this research provides a robust framework for addressing the multifaceted challenges of urban mobility.

The anticipated outcomes of this study include the development of a comprehensive traffic flow model based on continuity and conservation equations, which can accurately simulate vehicle movements and predict congestion hotspots. Additionally, the creation of efficient algorithms for dynamic signal optimization and route management will significantly enhance the adaptability of traffic control systems, minimizing delays and improving overall flow efficiency. Furthermore, the integration of Intelligent Transportation Systems (ITS) with these models offers a data-driven approach to real-time traffic monitoring and adaptive control, leading to reduced travel times, lower fuel consumption, and diminished environmental impacts such as CO2 emissions.

Future work will focus on the real-world deployment of the proposed models and algorithms in pilot cities, representing diverse traffic patterns and infrastructure settings. This phase will involve rigorous testing and validation under varying conditions, ensuring scalability and effectiveness. By assessing the performance across different urban contexts, this research aims to refine its methods and provide actionable insights for transportation planners and policymakers.

Ultimately, this approach promises to deliver significant advancements in urban traffic management. It has the potential to benefit commuters through reduced congestion and improved travel experiences, while also addressing broader societal goals, such as environmental sustainability and enhanced road safety. The findings of this research underline the critical role of formal methods and intelligent systems in shaping the future of urban mobility.

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Metode formale pentru modelarea, analiza și optimizarea dinamică a traficului rutier

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Abstract
Această cercetare se bazează pe lucrările existente în modelarea fluxului de trafic, tehnicile de optimizare și Sistemele Inteligente de Transport (ITS). Studiile privind metodele de optimizare Lagrange și algoritmii adaptivi în timp real au fost fundamentale, la fel ca și lucrările anterioare care au integrat ITS în rețelele urbane de trafic. Studii conexe publicate în *SCRD Journal* și *SCIC Proceedings* evidențiază importanța tot mai mare a sistemelor de gestionare dinamică a traficului pentru o planificare urbană durabilă. Această cercetare extinde aceste concepte prin abordarea lacunelor legate de adaptabilitatea în timp real și optimizarea mediului. Studiul utilizează o metodologie hibridă care include modele de simulare a fluxului de trafic, optimizare algoritmică prin metode Lagrange și integrarea datelor reale din ITS. O combinație de studii de caz și analize empirice evaluează eficacitatea modelelor propuse. Simulările includ variabile dinamice, cum ar fi densitatea traficului, complexitatea rețelei rutiere și indicatorii de mediu, asigurând o evaluare cuprinzătoare. Rezultatele demonstrează îmbunătățiri semnificative în eficiența fluxului de trafic, cu reducerea nivelurilor de congestionare și a emisiilor de CO2 cu până la 20% în condiții simulate. Modelele propuse îmbunătățesc, de asemenea, gestionarea adaptivă a traficului, arătând capacitatea de reacție în timp real la fluctuațiile din tiparele de trafic. Această cercetare oferă perspective valoroase pentru mediul academic, planificatorii de transport și factorii de decizie politică. Pentru cercetători, oferă un cadru pentru integrarea metodelor formale cu tehnologiile ITS. Pentru practicieni, conturează strategii practice pentru implementarea soluțiilor de trafic sustenabile din punct de vedere ecologic. Contribuția esențială a studiului constă în integrarea metodelor formale cu optimizarea dinamică a traficului, oferind o abordare unică și practică pentru abordarea provocărilor traficului urban. Originalitatea cercetării asigură relevanța acesteia în avansarea sistemelor de transport sustenabile și inteligente.

1. Introducere
Congestionarea traficului rutier reprezintă o provocare în creștere în mediile urbane, contribuind la întârzieri semnificative, emisii crescute și costuri economice ridicate. Sistemele tradiționale de gestionare a traficului se confruntă cu dificultăți în adaptarea la natura dinamică și complexă a traficului urban, necesitând metodologii avansate care să valorifice cadre formale și adaptabilitatea în timp real. Această cercetare abordează aceste provocări prin propunerea unei integrări inovatoare a metodelor formale cu Sistemele Inteligente de Transport (ITS) pentru a modela, analiza și optimiza dinamic fluxurile de trafic. Astfel de abordări se bazează pe cercetări anterioare privind schimbul de date în sistemele de comunicare între vehicule [1], algoritmii de detectare a anomaliilor în traficul urban [2] și generarea de modele de rețea folosind algebre de evaluare a performanței [3].

Studiul explorează modele de flux de trafic, inclusiv automatele celulare, sistemele multi-agent și simulările fluid-dinamice, pentru a prezice punctele de congestionare și a îmbunătăți fluxul de trafic. Pentru gestionarea constrângerilor, cum ar fi capacitatea intersecțiilor și sincronizarea semafoarelor, se utilizează tehnici de optimizare Lagrange, având scopul de a minimiza întârzierile și a îmbunătăți eficiența sistemului. Integrarea ITS oferă date în timp real provenite de la senzori și algoritmi predictivi, permițând ajustări dinamice ale parametrilor de trafic pentru reducerea congestiei și a emisiilor.

1.1. *Obiectivele cercetării*

Această cercetare urmărește atingerea următoarelor obiective:
• Dezvoltarea de algoritmi robusti pentru optimizarea fluxului de trafic și a sincronizării semafoarelor;
• Proiectarea unor modele predictive pentru densitatea și fluxul de trafic în condiții variabile;
• Implementarea strategiilor de optimizare dinamică pentru a reduce congestionarea și emisiile de CO2.

1.2. Metodologie

Abordarea propusă combină metode matematice formale cu tehnologiile ITS. Utilizând modele bazate pe simulare și cadre de optimizare, tiparele de trafic sunt analizate în scenarii variate. Date reale din sisteme de trafic urban îmbunătățesc acuratețea modelelor, asigurând aplicabilitatea practică. De exemplu, tehnicile revizuite în [4] oferă perspective asupra învățării prin întărire pentru optimizarea fluxului de trafic, în timp ce modelele bazate pe agenți discutate în [5] subliniază potențialul sistemelor adaptive, descentralizate.

1.3. Implicații

Cercetarea oferă o valoare semnificativă pentru mediul academic, planificatorii de transport și factorii de decizie, prin furnizarea unui cadru scalabil și adaptabil pentru gestionarea traficului urban. Aceasta sprijină dezvoltarea orașelor sustenabile prin creșterea eficienței traficului și conservarea mediului.

Originalitatea acestui studiu constă în aplicarea metodelor formale pentru optimizarea traficului în timp real, umplând un gol esențial în metodologiile existente. Abordarea sa interdisciplinară leagă modelarea teoretică de implementarea practică, oferind o contribuție valoroasă domeniului sistemelor inteligente de transport.

2. Ilustrații

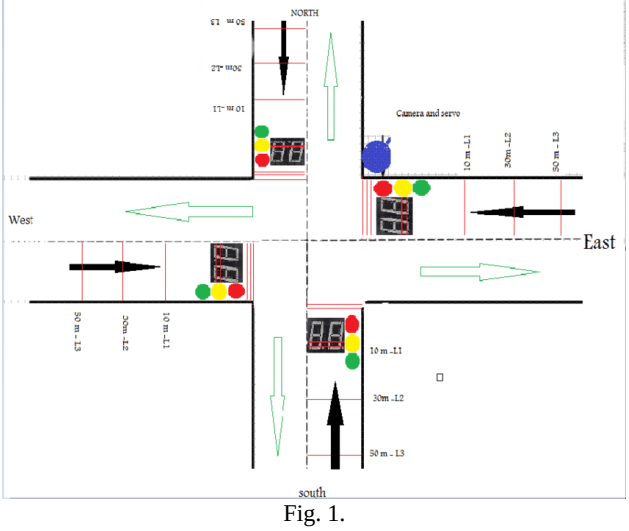

Fig. 1.
Source: Traffic-intersection-with-four-direction-and-single line

3. Ecuații

$$\frac{\partial \rho}{\partial t} + \frac{\partial (\rho v)}{\partial x} = 0$$

Unde:

- ρ : :Densitatea traficului
- v : Viteza
- t : Timpul
- x : Pozitia

Conservarea fluxului de traffic

$$\boldsymbol{q = \rho v}$$

Unde: q reprezinta fluxul de trafic (vehicule/unitate de timp)

Lagrange

Pentru optimizarea traficului, funcția Lagrange combină funcția obiectiv și constrângerile:

$$\mathcal{L}(x, \lambda) = f(x) + \lambda(g(x) - c)$$

Unde:

- f(x): Funcția obiectiv (de exemplu, minimizarea timpului de așteptare)
- g(x): Constrângeri (de exemplu, capacitatea traficului)
- λ : Multiplicatori Lagrange
-

Exemplu pentru optimizarea intersecției: Funcția obiectiv: Minimizarea timpului total de așteptare:

$$(x) = \sum_{i=1}^{n} T_i(x)$$

Constrângere: Fluxul de trafic nu trebuie să depășească capacitatea intersecției:

$$g_i(x) = x_i - C_i = 0$$

Rezolvarea sistemului de ecuații derivat din:

$$\frac{\partial L}{\partial x_i} = 0, \frac{\partial L}{\partial \lambda} = 0$$

Condițiile Karush-Kuhn-Tucker (KKT) Pentru constrângeri de tip inegalitate:

$$h_j(x) \leq 0, v_j(x) \geq 0, v_j(x) \cdot h_j(x) = 0$$

Acestea permit includerea limitărilor din lumea reală, cum ar fi prioritatea vehiculelor de urgență sau a transportului public.

4. Concluzii

Aplicarea metodelor formale în gestionarea traficului rutier reprezintă un pas transformator către realizarea unor sisteme de transport urban eficiente, sustenabile și sigure. Prin integrarea modelării matematice, tehnicilor avansate de optimizare și analizelor de date în timp real, această cercetare oferă un cadru robust pentru abordarea provocărilor complexe ale mobilității urbane.Rezultatele anticipate ale acestui studiu includ dezvoltarea unui

model cuprinzător de flux de trafic bazat pe ecuațiile de continuitate și conservare, care poate simula cu precizie mișcările vehiculelor și poate prezice punctele de congestionare. În plus, crearea de algoritmi eficienți pentru optimizarea dinamică a semafoarelor și gestionarea rutelor va îmbunătăți semnificativ adaptabilitatea sistemelor de control al traficului, minimizând întârzierile și îmbunătățind eficiența fluxului general. Mai mult, integrarea Sistemelor Inteligente de Transport (ITS) cu aceste modele oferă o abordare bazată pe date pentru monitorizarea în timp real a traficului și controlul adaptiv, ceea ce va conduce la timpi de călătorie reduși, consum de combustibil mai mic și impacturi ecologice diminuate, precum emisiile de CO2. Munca viitoare se va concentra pe implementarea în lumea reală a modelelor și algoritmilor propusi în orașele pilot, care reprezintă tipare de trafic și setări infrastructurale diverse. Această fază va implica teste riguroase și validare în condiții variate, asigurând scalabilitatea și eficiența. Evaluând performanța în diferite contexte urbane, această cercetare urmărește să îmbunătățească metodele sale și să ofere perspective utile pentru planificatorii de transport și factorii de decizie politică. În cele din urmă, această abordare promite să aducă progrese semnificative în gestionarea traficului urban. Are potențialul de a aduce beneficii călătorilor prin reducerea congestionării și îmbunătățirea experienței de călătorie, în timp ce abordează și obiectivele societale mai largi, cum ar fi sustenabilitatea ecologică și siguranța rutieră îmbunătățită. Rezultatele acestei cercetări subliniază rolul esențial al metodelor formale și al sistemelor inteligente în modelarea viitorului mobilității urbane.

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Securitatea Republicii Moldova și evidențe ale necesității de consolidare a rezilienței

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Abstract
Securitatea Republicii Moldova (RM) este o problematică care a fost și continuă a fi o permanență. Frecventele crize cu care s-a confruntat a canalizat atenția spre alte subiecte decât cel de securitate. Războiul din Ucraina a scos la suprafață și definit multiplele vulnerabilități ale RM în fața pericolelor de securitate și incapacitatea efortorilor autorităților de a face față acestora din cauza unei societăți dezbinate. În acest context, scopul cercetării este de a analiză mecanismele de guvernare capabile de a consilida rezilența RM și a constibui la edificarea unei societăți inteligente și autoimune în fața pericolelor de securitate. Cercetarea are ca suport teoretico-metodologic paradigma abordării interdisciplinare și transversale, elaborată și aplicată pentru culegerea și prelucrarea datelor. Ca rezultat al aplicării acestui arsenal teoretico-metodologic au fost obținute rezultate, care au scos în evidență cauze, factori de risc și soluții care necesită a fi reconsiderați într-un exercițiu de consolidare a rezilienței RM în fața pericoleler la adresa securității. Valoarea cercetării și utilitatea practică a acesteia este confirmată de exercițiul recent al alegerilor prezidențiale din RM și referendumului, ceea ce confirmă importanța și valoarea concluziilor formulate și necesitatea de a elabora un proiect de țară în cheia consolidării societății prin cetățeni responsabili, implicați, raționali și capabili de a lua decvizii inteligente.

Cuvinte cheie: guvernare, vulnerabilități, securitate, reziliență, crize, raționalitate, societăți inteligente.

1. Introducere
Republica Moldova, un stat mic, aflat la granița dintre est și vest, a realizat progrese lungi și lente spre democrație și stat de drept. Ea a rămas să fie printre statele fragile, chiar dacă au fost periodic înregistrate tranziții istorice, dar secvențiale spre comunitatea statelor europene. În acest sens, în articolul *Dilema modernizării și construcția credibilității* s-a arătat că **„**evaluarea proceselor politice din Republica Moldova a indicat imposibilitatea construcției și coagulării unei viziuni consensuale cu referire la traseul de dezvoltare a Republicii Moldova, pentru o perioadă destul de îndelungată. Practic, fiecare legislativ a înregistrat blocaje, crize politice care au declanșat la rândul său crize de guvernare, ce au bulversat societatea [1]”.

Din 2020 până în prezent, necătând la problemele generate de criza pandemică și războiul din Ucraina, cetățenii RM au asistat la evoluții de excepție pe plan extern și la acțiuni întreprinse de autoritățile naționale ce au impulsionat recunoașterea internațională și la o altă percepție asupra tranzițiilor și reformelor din țară. Dacă până la acestă perioadă RM era percepută, mai degrabă, ca o țară ce era dominată de preferințe pro rusești, atunci în acești ultimi ani ea a devenit un stat ce și-a definit propriul parcurs și s-a orientat spre comunitatea internațională, cu autorități implicate și bine intenționate.

Analiza dinamicii proceselor, a impactului actului decizional asupra dezvoltării umane definește consecvența scopului urmărit de guvernare. În același timp, dinamica proceselor și deciziile guvernării în vederea realizării unei tranziții cât mai rapide spre comunitatea statelor UE au creat un spațiu de ruptură între guvernare și cetățeni, care sub povara grijilor și propriilor nevoi să nu conștientizeze avantajele și relevanța eforturilor depuse și pașilor întreprinși spre bunăstrare și îmbunătățirea situației socio-economice per ansamblu.

În prezent, Republica Moldova se confruntă cu provocări complexe, accentuate de factori interni și externi, inclusiv tensiunie geopolitice, vulnerabilități economice și probleme de securitate cibernetică. Evoluțiile recente din țară au indicat stringența necesității de consolidare a rezilienței din considerentul multiplilor factori de presiune și influență asupra securității RM.Toate acestea sunt raportate și unui context regional marcat de instabilitate, ceea ce impune măsuri de consolidare a rezilienței naționale pentru a proteja statul și cetățenii împotriva amenințărilor actuale și potențiale.

În acest context, se dezvoltă subiectul necesității de consolidare a rezilienței sociale, prin identificarea și analiza principalelor vulnerabilități de securitate care au devenit evidențe în perioada recentă a proceselor de modernizare și de inițiere a aderării RM la UE. Procesele derulate la nivel de țară, au fost însoțite de acțiuni ale unor actori interesați în destabilizarea situații din Republicii Moldova, contribuind la dezbinarea societății moldovenești.

Pentru a avea claritate cu privire la vulnerabilități și riscuri s-a apreciat ca utile și eficiente sugestiile metodologice formulate de către N. Albu care pentru facilitarea procesului de identificare și apreciere a amenințărilor și riscurilor pe termen mediu și lung înaintează o metodologie, bazată pe evaluarea structurată care fiind aplicată va „facilita formularea recomandărilor de politici și acțiuni care vor diminua riscurile și vor spori reziliența Republicii Moldova în fața amenințărilor existente, precum și identificarea capabilităților de bazăpentru a ajuta la identificarea tipurilor de incidente care reprezintă cea mai mare amenințare pentru securitatea națională” [2].

Ca repere teoretico-metodoliogice a acestui articol au servit și datele obținute în cadrul cercetărilor realizate în contextul programului „Modernizarea mecanismelor de guvernare axate pe protecția drepturilor omului,” care a punctat impedimentele de modernizare a RM și a identificat soluții în acest sens. Pe această dimensiune se valorifică date obținute în cadrul unor studii [3] care au constatat că ritmul alert de derulare a proceselor, dezvoltarea rapidă a tehnologiilor, dar și evoluțiile sociale, economice, politice, juridice generează un grad înalt de vulnerabilitate a ordinii de drept, a legitimității puterii, iar situațiile de criză tot mai frecvente, au impact negativ asupra interacțiunilor dintre cetățeni și autorități, procesul de comunicare fiind mai dificil de realizat, standardele juridice mai puțin eficiente și aplicabile, iar nemulțumirea tot mai mare.

2. Raționalizarea și conștientizarea propriilor vulnerabilități

Luând în considerare evoluțiile în semnificațiile atribuite conceptului de securitate, menționăm preferința pentru o formulă extinsă prin care sunt vizați toți actorii ce au legitimitate în supravegerea și asigurarea securității statului și a cetățenilor. Astfel, se

prezentă o analiză generalizată prin care se definește imaginea unor vulnerabilități cuprinzătoare a stării de securitate a Republicii Moldova, care accentuiază măsurile necesare pentru a asigura stabilitatea și reziliența națională în fața unor provocări tot mai complexe.

2.1. Cadru conjugat de asigurare a rezelienței la nivel european

În 2016, ca răspuns la un mediu de securitate tot mai complex, caracterizat de noi provocări precum migrația, schimbările climatice și amenințările cibernetice, UE a adoptat o nouă Strategie Globală. Această strategie a oferit o direcție mai amplă și a abordat aspecte precum reziliența societală și apărarea comună. De asemenea, au fost lansate inițiative precum PESCO (Cooperarea Structurată Permanentă), care a oferit un cadru de cooperare mai strâns în domeniul securității și apărării între statele membre.

În 2020 a fost prezentată Strategia UE privind uniunea securității, care pune accent pe consolidarea capacităților de răspuns eficient și coordonat la amenințările în evoluție rapidă și protejarea tuturor cetățenilor UE. În comunicarea comisiei referitoare la Strategia UE privind uniunea securității se remarcă abordarea securității printr-o echilibrare a acesteia pe plan individual și social. „Securitatea nu reprezintă doar baza siguranței personale, ci contribuie, de asemenea, la protejarea drepturilor fundamentale și constituie temelia încrederii în economia noastră, în societatea noastră și democrația noastră, precum și a dinamismului acestora [4].”

Implementarea Strategiei Europene de Securitate (SES) a reprezentat un pas important în consolidarea rolului UE ca actor global de securitate, însă procesul a fost limitat de unele divergențe dintre statele membre și de lipsa unor resurse comune de apărare. Cu toate acestea, Strategiei Europene de Securitate a pus bazele unei colaborări mai bune în domeniul securității și a oferit UE un cadru strategic pentru a răspunde amenințărilor. Astfel, Strategiei Europene de Securitate rămâne un punct de referință în politica de securitate a UE, oferind o fundație solidă pentru eforturile viitoare în domeniul securității și apărării. Mai mult, pentru comunitatea europeană securitatea în imediata apropiere este o prioritate deoarece „Obiectivul este consolidarea prosperității și a stabilității acestor țări și, astfel, a securității UE. Propunerile acoperă o gamă largă de domenii de cooperare bilaterală și multilaterală, inclusiv securitatea energiei și mobilitatea persoanelor [5].”

Raportul cu privire la punerea în aplicare a SES menționează că provocările la adresa securității identificate la etapa de elaborare a acesteia au rămas valabile și după cinci ani de implementare a strategiei, din acest motiv „Pentru a ne asigura securitatea și a satisface așteptările cetățenilor noștri, trebuie să fim gata să modelăm evenimentele. Aceasta înseamnă să devenim mai strategici în gândire și mai eficienți și mai vizibili în lume. Obținem cele mai mari succese când operăm într-un mod coerent și în timp util, utilizând capacitățile corespunzătoare și benefi ciind de un sprijin public susținut [5].” De asemeni, în evaluarea progreselor înregistrate prin implementarea SES se face referință și la politica europeană de vecinătate, menționându-se intenția de inițiere a negocierilor cu Republica Moldova pentru a semna un acord de asociere. Anume în această direcție lucrurile au avansat, dat fiind etapa actuală la care s-a derulat screeningul bilateral dintre RM și Comisia Europeană.

Astfel, pilonul central al politicii de securitate a UE s-a consolidat în jurul Strategiei de securitate adoptate. Scopul prioritar al strategiei fiind consolidarea capacităților UE de a preveni și răspunde amenințărilor globale, cu accent prioritar pe un cadru strategic care să ghideze eforturile comune ale statelor membre și ale instituțiilor UE în vederea protejării cetățenilor europeni și a promovării păcii și stabilității internaționale.

În context regional și internațional, în prezent se atestă eforturi conjugate ale actorilor internaționali de a-și consolida capacitățile pentru a asigura securitatea la nivel regional, ca etapă intermediară de asigurare a stabilității la nivel global. Parteneriatul de Securitatea și Apărare între RM și UE indică că „Uniunea Europeană și Republica Moldova se confruntă cu un mediu de securitate din ce în ce mai dificil, printre altele din cauza războiului de agresiune al Rusiei împotriva Ucrainei. UE și Moldova s-au angajat să consolideze ordinea internațională bazată pe norme și să susțină respectarea Cartei Organizației Națiunilor Unite (ONU) [6]."

Subiectul securității RM a fost fregvent abordat în discuțiile dintre oficiali în diverse formate. Recent, în cadrul vizitei oficiale a presedintelui României Klaus Iohannis în Germania, la întrevederea cu cancelarul Republicii Federale Germania, Olaf Scholz [7] s-a pus problema necesității unui sprijin susținut al Republicii Moldova pentru asigurarea securității și bunăstării cetățenilor. Aceste discuții a fost determinate de procesele recente din Republica Moldova care au scos în evidență interferențe externe majore prin care s-a influențat actul decizional al cetățenilor în cadrul scrutinului electoral și referendumului, ceea ce a precipitat și reorientarea atenției spre vulnerabilități, care se identifică la nivel de societate și care trimit la consolidarea eforturilor de reconceptualizare a actului decizional și de remodelare a societății în cheia propriilor interese naționale.

Avînd ca reper măsurile de asigurare a securității prin creșterea rezilienței UE și a acțiunilor întreprinse de alte state se va urma analiza modului în care spațiul de securitate din RM, chiar dacă au fost întreprinse măsuri menite să crească eficiența instituțională și reziliența, mai continuă a fi expus pericolelor interne și externe.

2.2. Neutralitatea și efortul de consolidare a capacităților de asigurare a securității

Analiza contextului actual definește modul în care au evoluat și s-au proliferat riscurile de securitate la nivel național și regional, având în vedere tensiunile geopolitice, dependența energetică și provocările economice. Problematica securității RM nu a fost în parcursul de dezvoltare modernă a țării o prioritate a autorităților. Declarindu-se un stat neutru, statutul de neutralitate fiind consfințit de Constituția din 1994 (art.11), RM a lăsat înafara atenției politica sa de securitate, prin care să-și afirme tranșant și clar poziția și să adopte mecanisme eficiente și capabile să asigure necesitatea de securitate a țării. Prevederea constituțională cu privire la statutul de neutralitate nu a protejat țara de imixiuni constante a Rusiei și amenințări clare cu privire la deciziile luate de guvernarea de la Chisinău, nici nu a putut decide asupra modului în care statutul de neutralitate poate contribui la evacuarea trupelor armate străine de pe teritoriul său. Încă în 2007 au fost elaborate studii care vorbeau despre caracterul inert al politicilor de securitate națională și necesitatea de reconceptualizare a sectorului, astfel încât securitatea să fie tratată „ [...] ca interes vital al statului. Considerând că nu există un alt scop mai presus de asigurarea securității, guvernele

ar fi logic să ia o atitudine prioritară [8].” În această direcție, aceiași sursă, indică că „toate guvernele (din Republica Moldova) din varii motive [...] au ignorat sectorul securității și i-au subiestimat importanța [...], au considerat cadrul de securitate ca fiind unul favorabil Moldovei [8].”

Analizele arată că problema majoră este că au fost neglijate pericole evidente, precum „dependența economică extremă față de Rusia [...] și tendința elitei politice de la Moscova de a menține controlul asupra guvernării de la Chișinău [8].” Astfel, pe de o parte, autoritățile moldovenești au fost anterior permisive intervențiilor și implicării Rusiei în treburile sale interne, ceea ce nu a permis soluționarea unor probleme de securitate pe care a continuat să le aibă pe parcursul a peste 30 de ani după independență. Riscurile evidente la adresa securității sunt cele care, pe de o parte, istoric au rămas nesoluționate, printre acestea fiind potențialul militar din regiunea transnistreană, prezența masivă a instrumentelor de propagandă și de dezinformare rusească, în special promovate și valorificate constant de partide politice pro-ruse, pe de alta, instabilitatea regională și războiul din Ucraina, care au acutizat emergența pericolelor.

Odată cu schimbarea vectorului politic și anunțată determinarea guvernării de la Chișinău, începând cu 2020, de a face parte din comunitatea europeană, au fost intensificate atacurile asupra Republicii Moldova. Loialitatea față de Rusia, din partea guvernării nemaifiind aceeași ca și în trecut, a determinat nu doar intensificarea, dar și diversificarea formelor de intervenție și imixiune în procesele democratice din Republica Moldova. Deaceea în prezent tot mai mulți experți, analiști, cetățeni își pun semne de întrebare cu privire la statutul de neutralitate al țării, daca mai este el valabil în aceste condiții? Ori poate că pe bune „neutralitatea Moldovei constituie de fapt, vulnerabilitatea ei? [8]”, subiect abordat și în alte cercetări care susțin că „neutralitatea minimizează posibilitățile unui stat mic de a căuta „surse externe de securitate [9].”

În unul dintre interviurile oferite de către directoarea *Centrului de Informare și Documentare NATO* se menționa despre amplele acțiuni de dezinformare și manipulare din spațiul mediatic moldovenesc cu privire la neutralitate și pericolele NATO pentru Republica Moldova. „Este un cerc vicios aici. Politicienii doresc mai multe voturi, dar electoratul nu cunoaște informația. Și atunci dau voturile nu neapărat la cei care ar dori ei să-i reprezinte în autoritățile de la nivel național. E o înțelegere eronată sau intenționat eronată a principiului de neutralitate și cooperarea cu diverse structuri de profil, cum ar fi NATO sau alte organizații la nivel regional și internațional sau lipsa înțelegerii de către unele partide politice, [...] a înțelegerii ce ar constitui această colaborare și atunci trebuie cetățenii, în primul rând, să înțeleagă și să exercite un fel de presiune asupra decidenților politici despre neutralitate, despre cooperare, despre securitate și opțiuni de securitate” [10]. Ca urmare a conștientizării riscurilor la care este expusă Republica Moldova au fost intreprinse măsuri de acoperire a golurilor pe dimensiunea securitate națională. Documentul de bază care vine să indice necesitatea de reconceptualizarea a statutului de neutralitate este *Strategia Națională de Securitate*, care face referință la state cu lungi tradiții de neutralitate care au renunțat în ultimii ani la acest statut pentru a-și garanta securitatea națională.

Îndubitabil, securitatea unui stat este dependentă de un șir de factori, printre care acțiunile și viziunea pe care o are guvernarea și obiectivele pe care le urmărește sunt definitorii. Primele acțiuni setate de prioretizare și conștientizare de către autoritățile de la Chișinău a necesității de fortificare a mecanismelor de asigurare a securității se identifică în activitatea legislativului, care a inițiat acțiuni orientate spre creașterea unui cadru de politici de securitate națională.

Evoluțiile semnificative pot fi identificate pornind de la deciziile și acțiunile întreprinse, ce au urmat după declarațiile din Parlamentul Republicii Moldova cu privire la prioretizarea subiectului securității naționale în dialogul cu Rusia, precum și lupta cu dezinformarea. În acest sens, în 2018 la inițiativa președinților Parlamentelor Republicii Moldova, Georgiei și Ucrainei a fost organizată *Conferința interparlamentară de securitate* [11], la care au fost puse în dezbatere probleme legate de securitatea informațională, energetică, apărare, precum și s-a discutat despre asigurarea creșterii economice stabile și a statului de drept în regiune.

De asemeni, Strategia Națională de Apărare, aprobată de Parlamentul RM în 2018 indica provocările cărora trebuie să răspundă autoritățile în următorii ani. „Securitatea de pe continentul european devine tot mai complexă. Din motive mai mult sau mai puţin explicite, unele state aleg să întreprindă acţiuni [...], care contravin principiilor dreptului internaţional", context în care „prin prisma aspirațiilor de integrare în spațiul cultural, economic și social european, Republica Moldova urmează să consolideze, să dezvolte și să modernizeze sistemul național de securitate și apărare, ținînd cont de evoluțiile mediului de securitate [12]."

Actuala *Strategie de Securitate Națională* indică un amplu spectru de actori care pot contribui la asigurarea unui mediu de securitate, indicându-se necesitatea dezvoltării și reformării instituțiilor de aplicare a legii și de înfăptuire a justiției, dezvoltarea unui sistem de securitate și apărare profesionist și modern, dar și o societate civilă implicată în stimularea unui parteneriat strâns între instituțiiile statului, sectorul nonguvernamental, mediul privat și diaspora. „Mediul global și cel regional de securitate se află într-o perioadă de volatilitate și de transformare accelerată. Această dinamică va necesita atenția și reevaluarea constantă din partea instituțiilor statului a politicilor de securitate și apărare în vederea ajustării lor, astfel încât Republica Moldova să poată contracara, în timp real, amenințările și riscurile la adresa ei realul actorilor vizați." De aceea această interdependență funcțională urmează să se materializeze în acțiuni și decizii concrete adoptate de guvernare în direcția asigurării securității și bunăstării cetățenilor săi, prin promovarea unei politici de securitate strategice, realiste, pragmatice, eficiente, funcționale și operaționale.

O altă platformă utilizată pentru a pune în atenția comunității internaționale necesitatea de consolidare a eforturilor comune și a necesității de suport pe dimensiunea securitate a fost *Forumul internațional de securitate de la București* [13] la care au fost puse în discuție riscurile, amenințările hibride și vulnerabilitățile din regiunea Mării Negre și a zonei Balcanilor. Președintele Parlamentului RM [14], care a participat la acest eveniment, a vorbit despre provocările de securitate cu care se confruntă în prezent Republica Moldova,

accentuând importanța realizării în timp proxim a procesului de aderare la Uniunea Europeană, pentru asigurarea securității. Un accent special a fost pus pe politica de vecinătate, reiterându-se rolul României în asigurarea securității Republicii Moldova și necesitatea fortificării în continuare a poziției unice cu Ucraina în păstrarea independenței statelor și asigurării securității.

Luându-se în considerare decizia Consiliului European din 2023 de a deschide negocierile de aderare cu Moldova și măsurile întreprinse de guvernare, progresele și reformele inițiate la Chișinău în direcția aderării la UE, a fost decisă stabilirea și implimentarea unui Parteneriat de securitate și apărare personalizat. Semnarea *Parteneriatului de Securitate și Apărare cu UE* urmărește să contribuie la consolidarea structurilor de gestionare a crizelor din Moldova și la creșterea rezilienței acesteia la amenințările hibride, totodată exprimă angajamentul Republicii Moldova și a Uniunii Europene să „dezvolte, să aprofundeze și să consolideze în continuare cooperarea și dialogul pe întreaga gamă de subiecte legate de securitate și apărare [...] cum ar fi amenințările cibernetice și hibride, inclusiv dezinformarea [15].”

Toate cele relatate supra se conjugă într-o perspectivă clară prin care se pare că s-a raționalizat importanța asigurării securității și au fost realizate progrese în acest sens. La nivel practic, totuși s-a precipitat problematica lipsei de eficiență a mecanismelor de asigurare a securității și bunăstării cetățenilor. Fie conectată la crizele din societate, fie la alte probleme mult mai profunde, pe segmentul securitate s-au proliferat pericole și vulnerabilități ce nu-și găsesc întotdeaună explicații logice, dar care necesită atenție și intervenție.

3. Eminența riscurilor și evidența pericoleleor

Diversificarea formelor prin care este ori poate fi amenințată securitatea, a justificăt în timp și incapacitatea unor state aflate în procese de tranziție, de a face față provocărilor cu care se confruntă, fapt ce a determinat autoritățile moldovenești să întreprindă măsuri urgente pentru a proteja integritatea și suveranitatea Republicii Moldova.

O problemă majoră pe care au încercat autoritățile să o elimine a fost dezinformarea. *Strategia Națională de Securitat*e [16] a identificat dezinformarea ca o importantă vulnerabilitate de securitate. Același lucru este semnalat la nivel global, dat fiind faptul că dezinformarea este apreciată ca un factor de risc important [17], care accentuează polarizarea politică și socială, slăbind coeziunea și reziliența națiunilor.

Un pas important în contracararea dezinformării a fost modificarea Codului audiovizualului în care au fost incluse norme care să asigure protecția persoanelor, societății și a statului de eventuale tentative de dezinformare sau informare manipulatorie. Prin amendamentele la lege s-a urmărit protecţia statului de tentative de dezinformare și manipulare din exterior și neadmiterea provocărilor cu caracter mediatic îndreptate împotriva Republicii Moldova. Chiar dacă a fost criticat pentru modul în care au fost puse în aplicare aceste modificări sunt totuși cele care am oferit unele mecanisme de intervenție, dat fiind conștientizarea faptului că spațiului informațional național este dominat de dezinformare, fenomen ce a luat amploare și a ajuns la torații înalte.

Luîndu-se în considerare amploarea fenomenului dezinformării, în 2023 a fost adoptat *Programul național de dezvoltare a mass-media pentru anii 2023-2026* și a fost creat *Centrul pentru Comunicare Strategică și Combatere a Dezinformării* [18] decizie adoptată și pe fondalul analize [19] care indică că în contextul procesului de aderare la UE, ca direcție strategică pentru Moldova, „Rusia nu (îi) va permite [...] să se îndepărteze din sfera sa de influență, amplificându-și acțiunile ce țin de războiul hibrid, precum propaganda și activizarea politică a „coloanei a cincea de politicieni pro-ruși". Aceeași analiză, ținând cont de afinități de limbă, cultură și tradiții, dar și din raționamente pragmatice indică două parteneriate strategice care trebuies explorate, acestea fiind România și Ucraina. România poate fi cea care va împărtăși experiența sa acumulată în cadrul procesului de aderare, facilitând prin expertiza deținută aderarea RM la UE, iar Ucraina, este un aliat al RM în asigurarea securității.

Pașii făcuți spre asigurarea securității și creșterii rezilienței totuși nu au fost suficienți și nu au reușit să facă față provocărilor la care este expusă țara și cetățenii. Pe lângă conflictul/războiul din regiune care „subminează fundamentele securităţii şi stabilităţii în zonă sau regiune" [20] au fost anunțate de către autorități imixiuni externe majore în contextul desfășurării referendumului, miza fiind pusă pe periclitarea parcursului european al RM, prin intervenții externe în scrutinul electoral din 2024.

Deci, *care sunt evidențele ce întăresc necesitatea consolidării societății în vederea creșterii rezilienței?*
Impactul Dezinformării: Referendumul și alegerile prezidențiale s-au dovedit un exercițiu solicitant și dificil pentru cetățenii RM, din considerentul că acesta a scos la suprafață o societate dezbinată și dominată de dezinformare și manipulare. Misiunea de Observare a alegerilor în Republica Moldova în Raportul interimar preciza faptul că „Peisajul mediatic este polarizat politic și se confruntă în mod constant cu provocări legate de manipularea informațiilor și de interferențele din străinătate. În plus, până de curând, o parte semnificativă a pieței media a fost controlată de instituții afiliate unor oameni de afaceri influenți. Guvernul a încercat să rezolve aceste probleme prin adoptarea de legi pentru combaterea dezinformării și prin adoptarea de măsuri restrictive pentru protejarea spațiului său informațional, inclusiv prin închiderea unor instituții media audiovizuale [21], acțiuni criticate și catalogate ca atentat la libertatea presei.

Problematica impactului dezinformării a fost una constantă în ultimii ani în analize, studii și rapoarte, [22], [23], [24] iar impactul lor resimțit în cadrul rezultatelor alegerilor. Studiile arată că datorită dezvoltării tehnologiilor informaționale, extinderii rețelelor sociale, progresului inteligenței articificale fenomenul dat a luat amploare și a marcat procesele democratice din state precum Republica Moldova. În acest sens, anul 2024, datorită referendumului și a alegerilor prezidențiale, a favorizat utilizarea spațiului informațional la maxim în direcția bulversării societății. Campania electorală a devenit un teren fertil pentru dezinformare, propagandă, manipulare, atât din exterior, cât și din interior, iar scindarea geopolitică un element indispensabil al narațiunii politicienilor.

Analiștii vorbesc deja despre tradiții de dezinformare și manipulare care s-au instituit în Republica Moldova [25]. Printre subiectele prioritare valorificate fiind cele care se referă

la UE și SUA, la „pericolele pe care acestea le-ar prezenta pentru independența și suveranitatea națională", „la tendința actualei guvernări de a atrage țara în război și de a destabiliza Transnistria", „la faptul că UE ne transformă în sclavi", la „distrugerea familiei tradiționale și închiderea școlilor" etc. Experții proceselor electorale au indicat că dezinformarea și propaganda au avut un impact major asupra felului în care au fost convinși cetățenii să voteze. Toate acestea au fost subiecte prezente în spațiul public și larg discutate pentru ca în consecință, dezinformarea să influențeze semnificativ votul alegătorilor, dar și să împartă societatea după criteriul **noi – ei.** Chiar dacă alegerile s-au încheiat, dezinformarea continuă să fie un factor distabilizator și să prezinte o serioasă amenințare la adresa securității naționale.

Asociația Presei Independente, a avut mai multe inițiative ce urmăreau explicarea și promovarea unității și coeziunii sociale (ex. *Toți pentru Moldova*" [26], *Stopfals* [27]), inclusiv autoritățile (Guvernul; Consiliul Suprem de Securitate, Serviciul de Informații și Securitate) conștientizând pericolele la adresa securității accentuau necesitatea solidarizării eforturilor în combaterea dezinformării, dar efectele acestora nu au fost pe măsură să depășească în mod substanțial practicile de dezinformare și să minimalizeze la maxim influența acestora.

Totalurile făcute de către autorități și experți, după scrutinul electoral din toamna acestui an, constată că dezinformarea a divizat oamenii și a provocat polarizarea societății. Dacă comparăm datele sondajelor din vara anului 2023 care arătau că 59,2% dintre cetățeni susțin aderarea la UE [28], la distanță de un an sondajele au arătat un procent de 51% de cetățeni ce susțin aderarea [28]. În acest sens, concluzia de bază care se înaintează în rezultatul observării modului în care a marcat dezinformarea rezultatele alegerilor, arată necesitatea stringentă a măsurilor de raționalizare a efectelor și de consolidare a societății pentru a crește reziliența acesteea în fața pericolelor la care poate fi expusă într-un secol tehnologizat și globalizat.

Impactul retoricii negative. Așa cum este cunoscut [29] retorica ori PR-ul negru se referă la metodele (imorale) utilizate în cadrul campaniilor electorale, ce fac uz de falsuri, materiale compromițătoare, atacuri la persoană etc. ce urmăresc denigrarea ori diminuarea reputației unei persoane. În acest sens, primul tur al alegerilor prezidențiale a fost caracterizat de o creștere constantă a materialelor electorale cu conținut negativ și cu critici din partea tuturor candidaților la președinție la adresa unui singur candidat (M. Sandu). De asemenea, s-a accentuat un limbaj intolerant şi discriminatoriu, deseori răspândit pe rețelele sociale, din partea candidaților la funcția de președinte din primul tur, la fel orientate împotriva unui singur candidat. În plus, au fost semnalate cazuri de campanii orchestrate pe rețelele sociale pentru a răspândi dezinformarea și pentru a manipula opinia publică (inclusiv prin promovarea unor mesaje anti-europene).

În cel de-al doilea tur al alegerilor prezidențiale retorica neagră a fost utilizată în raport cu ambii candidați rămași în cursă. De asemenea, diverse entități politice au recurs la mesaje care prezentau scenarii apocaliptice în cazul unui eșec al propriului candidat, consolidând un discurs polarizant și alarmist.

În consecință, toate acestea au avut impact asupra societății, accentuând și mai mult diviziunea politică și socială și contribuind la diminuarea încrederii în actuala guvernare a țării și a importanței procesului de aderare la UE [30]. Mai mult, retorica negativă a redus nivelul încrederii în procesul electoral și în instituțiile democratice, în timp ce susținătorii diferitelor tabere politice au devenit tot mai radicalizați.

Analiza de conținut a discursului politic din campania electorală recentă rămâne a fi un subiect deschis și necesar analizelor, pentru a putea defini evoluțiile posibile de viitor, în special în raport cu alegerile parlamentare care vor fi peste un an. În cazul dat concluzionăm că recursul la retorica neagră a influențat semnificativ climatul socio-politic din Republica Moldova, în special datorită faptului că a fost realizată diseminarea masivă a informațiilor denigratoare și instigarea la diviziune pe criterii etnice și geopolitice. Astfel, retorica neagră utilizată în campania prezidențială din Moldova a contribuit și ea la polarizarea societății, consolidând o atmosferă de neîncredere și tensiune, care va necesita măsuri imediate și active pentru reconcilierea și restabilirea dialogului civic.

Decizii nepopulare a guvernării. Atât președintele Maia Sandu, cât și partidul PAS au avut o susținere impunătoare la alegerile anterioare. Promisiunile importante făcute de aceștea veneau ca răspuns la probleme stringente ale societății. Printre cele mai importante promisiuni și așteptate a fi realizate se înscrie reforma justiției, lupta cu corupția și dezoligarhizarea. Dar în contextul crizelor, cărora a trebuit să facă față (pandemia, șantajul energetic, războiul și criza refugiaților) eforturile și atenția autorităților au fost reorientate spre alte probleme cu care se confrunta societatea, statul și cetățenii: asigurarea păcii, soluționarea crizei energetice, prioritizarea acțiunilor în vederea realizării pașilor spre integrare în UE ș.a.

În același timp, mai multe decizii ale guvernării au fost supuse criticilor și dezaprobării. Printre acestea se înscrie și punerea în aplicare a mecanismelor de evaluare externă a procurorilor și judecătorilor prin care se urmărește asigurarea integrității și sporirea încrederii societății în justiție a adus după sine, rezistență, demisii și multiple critici. Criticile au vizat reforma justiției, considerată lentă și insuficientă și cea mai controversată decizie a guvernării, iar reformele structurale de lupta împotriva corupției lipsite de eficiență și de rezultate concrete. În special, cel din urmă aspect s-a accentuat în contextul alegerilor prin corupție electorală.

Astfel, realizările importante, în special pe plan extern, au fost mult mai semnificative și palpabile decât cele interne. De asemenea, trebuie de menționat și faptul că politica pro-europeană fermă a fost contestată de opoziție și de unele segmente ale populației, mai ales în contextul creșterii costurilor vieții și a unor decizii economice percepute ca insuficient de favorabile pentru cetățeni. În consecință, deciziile nepopulare ale guvernării au creat probleme de acceptare și au contribuit la formarea percepțiilor negative.

Regionalizarea preferințelor. Un alt moment important al scrutinului se referă la caracterul pronunțat al efectelor influențelor majore în context regional. Chiar dacă a fost promovată o politică echilibrată de către autorități, orientată spre susținerea dezvoltării uniforme a RM totuși s-a accentuat o discrepanță majoră în raport cu unele regiuni a țării.

Strategia Națională de Dezvoltare Regională a RM 2022-2028 [31], modificările operate la Legea nr.438 privind dezvoltarea regională a RM [32], care urmăresc (art.2.(1)) „creșterea competitivității și dezvoltarea durabilă a fiecărei regiuni, reducerea disparităților și sporirea calității vieții locuitorilor", totuși au fost insuficienți pentru a abordare uniformizată, rămînând accentuate diferențele și preferințele cetățenilor. Alegerile prezidențiale și referendumul privind integrarea europeană au arătat clar modul în care este polarizată socio-politic țara.

Rezultatele strânse ale referendumului constituțional pro-UE au evidențiat diviziunile dintre regiunile țării și diaspora, indicând provocări în menținerea susținerii pentru vectorul pro-european și necesitatea concentrării eforturilor spre problemele interne și spre apropierea de necesitățile cotidiene a cetățenilor. În conformitate cu datele prezentat de către Comisia Elecorală Centrală se poate de vorbit despre: - zone pro-European (centrul republicii și capitala). Astfel, în regiunea centrală (ex. Ialoveni, Strășeni, Hîncești), în Chișinău și în majoritatea suburbiilor Maia Sandu, fiind asociată cu orientarea pro-europeană, a câștigat, cu un scor de peste 60%. Votul dat în favoare președintelui reflectă susținere pentru aderarea la UE și orientarea către valorile europene, modernizare și consolidarea statului de drept; - zonele pro-ruse (Nord, Găgăuzia și Transnistria). Candidatul socialiștilor (Alexandr Stoianoglo), a dominat în regiunile din nord (ex. Ocnița, Briceni, Edineț) și în autonomia Găgăuzia, unde a obținut scoruri de peste 90%. În Transnistria, majoritatea voturilor exprimate au fost pentru același candidat, cu scoruri similare. Aceste rezultate ar putea fi considerate ca indicator al preferințelor pro-ruse a cetățenilor.

Spre deosebire de alegerile prezidențiale, datele referendumului pentru Integrarea Europeană, înregistrează o participare mai scăzută în zonele dominate de electoratul pro-rus. În Găgăuzia și alte regiuni nordice, rata de participare a fost relativ scăzută comparativ cu centrul țării, sugerând o lipsă de interes sau opoziție față de acest subiect. Referendumul fiind la limită în interiorul țării, a fost salvat (am putea zice) de votul diasporei. Alegătorii din diasporă au susținut în mare parte orientarea pro-europeană, reflectând priorități și experiențe diferite față de cei din regiunile rurale ale Moldovei. Aceste diferențe reflectă nu doar preferințe politice distincte, ci și divergențe culturale, economice și istorice care influențează deciziile cetățenilor și reflectă percepția cu privire la viitorul țării și a orientării sale geopolitice.

Corupția electorală. Corupția electorală, un fenomen cunoscut societății, a fost unul neestimat probabil de autorități la justa sa amploare. Măsurile luate de autorități prin intervențiile în legislație nu au avut efectul scontat. Tema corupției electorale a fost una centrală pentru alegerile prezidențiale, în special acestea au fost din abundență în turul doi al alegerilor. În preajma alegerilor, într-o perioadă scurtă de timp au fost organizate de către conducerea instituțiilor de drept (Inspectoratul General al Poliției, procuratura Generală) mai multe briefinguri și conferințe de presă prin care au fost atenționați cetățenii cu privire la riscuri eminente la adresa securității, printre acestea indicându-se acțiuni de distabilizare a ordinii constituționale, inclusiv atenționarea asupra eventualelor acțiuni de fraudare a alegerilor și de cumparare a voturilor.

Necâtând la măsurile luate în vederea anticipării cumpărării voturilor, totuși conform informațiilor prezentate de instituții de drept, alegerile au fost marcate de coruperea votului. Corupția electorală s-a manifestat prin mai multe metode, care au variat de la influențe financiare directe asupra alegătorilor până la utilizarea resurselor externe și mecanismele ilegale de mobilizare a votului.

Între turul unu și doi a alegerilor prezidențiale instituțiile de drept au realizat percheziții și investigații în mai multe localități, vizând fapte de corupție electorală; au fost monitorizate transferuri financiare destinate coruperii electoratului, au fost documentate persoane pentru că ar fi acceptat bani în schimbul votului pentru un anume candidat. Perioada premergătoare celui de-al doilea tur de scrutin a fost marcată de continuarea investigațiilor asupra interferenței din străinătate și a schemelor de cumpărare a voturilor, pentru a influența rezultatele alegerilor și referendumului, inclusiv percheziții la sedii, rețineri ale persoanelor fizice, capturarea de materiale și aplicarea amenzilor [33]. Organele de drept au estimat că numărul persoanelor fizice implicate ar putea depăși 300.000 și că „sumele de bani alocate coruperii electorale din ultimii doi ani ar putea ajunge la sute de milioane de dolari." Reprezentanți ai autorităților au vorbit și despre faptul că au fost create întregi rețele criminale de cumpărarea a voturilor, iar observatorii au constatat și înregistrat faptul că „dificultățile create de interferența străină și schemele de cumpărare a voturilor au continuat să se răsfrângă asupra campaniei pentru turul doi de scrutin [34].

Datele recente prezentate de *Centrul Național Anticorupție* informează că până la data de 22 noiembrie 2024 au fost aplicate amenzi în valoare de peste 7 milioane de lei pe marginea proceselor verbale, recepționate de la Poliție, cu privire la constatarea contravenției prevăzute de articolul 47 Cod Contravențional [35] „Cele două tururi ale alegerilor prezidențiale și referendumul constituțional din 2024 au avut loc într-un context în care guvernul s-a confruntat cu amenințări la adresa securității naționale [...]. Organele de drept, numeroși actori internaționali și societatea civilă au anunțat că Moldova este ținta unui război hibrid în desfășurare, direcționat din străinătate, ce include diverse forme de interferență manipulativă pentru a destabiliza țara, finanțare ilicită a actorilor politici, campanii de dezinformare și atacuri cibernetice [36].

Metode de corupție electorală utilizate au avut scopul de a afecta integritatea alegerilor și de a crea avantaje nelegitime pentru anumite forțe politice. Deși guvernarea a luat măsuri pentru combaterea acestor fenomene, amploarea lor a indicat că problema rămâne una structurală și necesită soluții pe termen lung.

Rezultatele alegerilor au arătat odată în plus că instituțiile slabe, persoane corupte, societate dezbinată și lipsa de coeziune socială, dezinformarea sunt un pericolul intern major. În același timp impotența instituțiilor naționale în fața intervențiilor externe continuă să scadă încrederea cetățenilor în procesele democratice, în capacitatea autorităților de a face față riscurilor, dar mai mult decât orice a arătat necesitatea consolidării legislative, instituționale și sociale în Republica Moldova.

4. Concluzii: Între teoretizare și pași de urmat

Dezinformarea și falsurile au devenit un serios pericol la adresa securității statului și a cetățenilor, au generat confuzii, au modificat discuțiile publice și au influențat modul în care sunt luate decizii. Toate aspectele identificate arată că trecem prin perioade dificile în care s-a aprofundat neîncrederea în autorități, au fost evidențiate mișcări populiste și chiar cu caracter extremist, au fost expuse poziții orientate spre radicalizare, fiind contestate valori democratice esențiale. Or, „Dezinformarea erodează încrederea în instituții, [...] are efecte nocive asupra democrațiilor noastre prin afectarea capacității cetățenilor de a lua decizii în cunoștință de cauză. […] Diverși actori interni și străini utilizează pe scară largă campaniile online de dezinformare în masă pentru a semăna neîncredere și a crea tensiuni societale, cu consecințe potențiale grave pentru securitatea noastră [37].” Astfel, dezinformarea și falsurile suplinite de celelate evidențe formulate (regionalizare, corupere etc.) au generat:

- Deficit de comunicare și informare
- Deficit de încredere
- Deficit de angajamente
- Deficit de legitimitate
- Deficit de solidaritate și coeziune socială

În acest context, pornind de la ideia schimbării de paradigmă în practica de guvernare, definirea priorităților de securitate pentru dezvoltarea democratică a Republicii Moldova, în vederea fundamentării necesității de consolidare a rezilienței, se va urma istoria recentă a unor tranziții și realizări, trecute prin filiera unui obiectiv comun de consilidare a societății. În acestă perspectivă, guvernarea este tratată printr-o abordare extensivă, ce plasează noțiunea dată în raporturi de dependență prin conceptul de autoritate, de legitimitate și capacitate. Tratată în cheia acestor repere conceptuale se vor desprinde răspunsuri la întrebări precum: *Care sunt pașii întreprinși spre creșterea gradului de asigurare a securității și care au fost omisiunile? Care sunt factorii cu impact major asupra dezbinării societății?*

Radiografierea evoluțiilor recente impune revenirea la conceptualizarea problemelor identificate și definirea modului de schimbare de paradigmă în practica de guvernare, care ar putea aloca un loc central securității și bunăstării cetățenilor. Fundamentarea acestei schimbări se bazează pe conștientizarea problemelor mai vechi și mai noi, raționalizarea pericolelor și adoptarea deciziilor și acțiunilor capabile de consolidarea societății pentru a asigura reziliența în fața pericolelor interne și externe.

Sunt trei concepte corelative care se reunesc într-o soluție sigură și eficientă: autoritatea, legitimitatea și capacitatea. În primul caz, cel al autorității, se referă la faptul că odată ce vorbim despre guvernare, ne referim la autoritatea recunoscută și investită cu putere de reglementare și decizie, adică o totalitate de instituții constituite într-un corp socio-statal comun, organizat conform prevederilor legale, care crează un spațiu de interacțiune a statului și societății. Dacă urmăm doctrina weberiană, în societate acceptarea autorității se plasează într-un context al beneficiilor aduse, adică autoritatea guvernării este determinată exclusiv de răspunsul dat în realizarea unor interese raționale [38].

Astfel, depășirea deficitului de încredere a guvernării în condiții precum cele descrise supra, este o sarcină destul de complicată. Totuși resetarea acțiunilor spre probleme interne, oferirea de soluții pentru depășirea dificultăților în cheia răspunsului la necesitățile persoanelor pot fi utile în această direcție, dar mai importantă va fi raționalizarea interesului comun al societății și consolidarea acesteia în realizarea la nivel național a proceselor de democratizare, a reformelor și a conștientizării pericolelor eminente, carăra este expus statul și cetățenii. Solidarizarea eforturilor ar putea deveni un scut sigur de protecție în fața amenințărilor interne și externe și de menținere a încrederii în autorități.

În cel de-al doilea caz, recunoașterea legitimității, se plasează într-un spațiu al rigorii juridice, al procedurilor, inclusiv al reperelor raționale a deciziilor nepopulare, care vor marca gradul de acceptare/neacceptare și susținere a guvernării de către cetățeni, fie datorită acțiunilor întreprinse, fie datorită unei ideologii promovate, fie realizărilor obținute.

Problematica legitimității este larg dezvoltată în literatura științifică, în special în teoria politică [39], dar și în știința juridică, fiind raportată dezbaterilor cu privire la teoria separației puterilor, dar și în alte contexte analitice. Ne vom opri la câteva aspecte specifice, pe care le identificăm relevante contextului.

Primo. Legitimitatea guvernării poate fi tratată prin prisma acțiunilor, proceselor pe care le inițiază și parcurge o guvernare (gestionarea crizelor, răspunsul la provocări, aderarea la UE etc.), fapt ce va aduce după sine susținere, ori nemulțumire. Așa cum indică unele analize a concepției weberiene „Cel mai adesea oamenii reacţionează socialmente sub efectul unei constrângeri de care pot fi mai mult sau mai puţin conştienţi. Aflându-se într-o astfel de situaţie, ei se supun unei ordini legitime. [...] Problema principală este aceea a gradului de acord sau dezacord cu ordinea dată, adică aceea a legitimităţii autorităţii. Când autoritatea este recunoscută (ca fiind validă) vorbim și despre legitimitatea ei [40].”

Secundo. Sursele tradiționale de legitimitate (Constituție, legislația, istorie, tradiții etc.) nu mai sunt autosuficiente, dat fiind dependențele globale, transformările și procesele tot mai complexe prin care trec statele (inclusiv Republica Moldova), care nu mai pot avea politici autonome și de răspuns adecvat nevoilor și aspirațiilor cetățenilor săi. Deaceea dezvoltarea parteneriatelor regionale și internaționale, efortul și dischiderea pentru implementarea bunelor practici în propriile tipare va fi un pas în depășirea deficitului de anagajament, în special în vederea asigurării bunăstării în societate.

Tertio. Dacă analizăm situația actuală din Republica Moldova, se constată și un dificit de legitimitate, dat fiind faptul că există nemulțimirea cetățenilor pentru anumite decizii adoptate, dar și promisiuni neîndeplinite. Pe de altă parte legitimitatea este afectată/marcată de criza economică, de criza socială, de probleme de securitate și de lipsa de rezultate palpabile. Cele mai mari realizări ale guvernării, recunoscute și de opoziția politică sunt cele externe, dar în același context au fost multiple alte provocări interne, probleme soluționate și progrese realizate despre care chiar dacă s-a vorbit totuși nu a ajuns la cetățean, ceea ce a generat dificitul de informare și comunicare.

În același timp, recentele alegeri prezidențiale (M. Sandu fiind asociată cu guvernarea PAS) la care a fost înregistrat un număr ridicat de participare este un indicator al recunoașterii legitimității, care, necătând la nemulțumirile exprimate prin scăderea încrederii în guvernare, totuși sunt un indicator al legitimității și al faptului că se recunosc eforturile depuse pentru a asigura consecvența actului de guvernare, liniștea și pacea în țară.

Ca rezultat, legitimitatea guvernării depinde atât de implementarea unor reforme vizibile și necesare pentru realizarea angajamentelor și creșterea încrederii cetățenilor, dar și deschiderea față de cetățeni pentru a menține echilibrul dintre sprijinul democratic intern, gestionarea eficientă a crizelor și menținerea relațiilor cu comunitatea internațională. Adică adoptarea perspectivei H. Arendt [41], [42], care dezvoltă legitimitatea în cheia acțiuni, consensului și a susținerii publice și cea a lui J. Hubermas [43], care în dezvoltarea conceptului de spațiu public ca loc al formării voinței colective prin integrarea drepturilor individuale cu voința colectivă, ca rezultat al unui proces de comunicare și deliberare rațională, prin comunicare și consens va contribui la consolidarea societății.

Cel de-al treilea este aprecierea capacităților. Capacitatea se referă la abilitatea unei guvernări de a concepe, implementa și susține politici publice eficiente, legitime și adaptative, care să răspundă nevoilor cetățenilor, să mențină ordinea socială și să gestioneze resursele în mod sustenabil, în conformitate cu principiile statului de drept. Weber indică că eficiența în sectorul public se obține prin respectarea regulilor, prin meritocrație și standarde și proceduri clare de accedere și promovare [44].

Aprecierea capacității guvernării este determinată de eficiența instituțiilor și a funcționarilor, angajați în acestea. Există modalități distincte ce pot fi utilizate pentru aprecierea/evaluarea capacităților guvernării, dar cei mai evidenți pentru interacțiunea guvernare-cetățeni sunt: - indicatorii cantitativ (indicile guvernării (Worldwide Governance Indicators, Banca Mondicală) și scoruri privind corupția, statul de drept, eficiența guvernării); - indicatorii calitativi (percepția cetățenilor, analiza discursurilor și strategiiilor de guvernare). În opinia noastră aceștea sunt palpabili și pot fi valorificați pentru a îmbunătăți starea de spirit și depăși deficiențele. Dacă consultăm informațiile din Indicele Guvernării (Worldwide Governance Indicators, WGI) al Băncii Mondiale, [45] pentru anul 2023 Republica Moldova a înregistrat progrese moderate în unele domenii, dar și provocări semnificative, în special la compartimentul stat de drept și controlul corupției, vedem că percepțiile rămân slabe comparativ cu alte state din regiune. La fel, dacă urmărim evoluțiile percepțiilor cetățenilor, în temeiul datelor înregistrate în *Baromenturul Opiniei Publice* [46], care permite analize comparative pot fi formulate aprecieri și cu privire la capacitățile guvernării. Utilitatea acestui exercițiu se referă la depășirea criticilor cu privire la nerealizarea angajamentelor și lipsa de eficientă. Or, analizele practic în unison indică că fără o administrație pregătită, loială și onestă, ori în lipsa unui personal dedicat funcției publice, vocației, guvernările nu vor putea realiza prea multe progrese. Deaceea capacitatea, accentuiază importanța profesionalizării pentru creșterea eficienței instituțiilor statului, adică a guvernării per ansamblu, și a capacității acestora de a răspunde necesităților sociale și economice, fapt ce va diminua deficitul de legitimitate.

Contextul actual fragil de securitate în regiune și din țară trimite la necesitatea unei perspective complementare, susținute de o pluralitate de acțiuni și eforturi solidare, cu o mai bună coordonare instituțională, însoțită de un proces de luare a deciziilor mai strategic capabil de a consolida societatea. Securitatea este un concept multidimensional și pentru a fi livrată cetățenilor necesită intervenții pe multiple planuri: politic, economic, social și ecologic, chiar și psihologic sau cultural. Or, la moment se atestă lipsa de cunoștințe cu privire la securitate, lipsa unei culturi a securității, deaceea pentru a putea fi asigurată mai întâi ea trebuie conștientizată. Pentru aceasta este necesară o mai mare vizibilitate a acțiunilor din partea autorităților și prezența mai masivă în societate a reprezentanților autorităților statului, pentru a fi mai aproape de cetățeni și pentru ai face să înțeleagă care este calea de dezvoltare benefică pentru țară, să cunoască mai bine realizările și progresele înregistrate, astfel contribuind la creștere aderenței societății la actul de guvernare și a coeziunii sociale.

În concluzie, alegerile prezidențiale din acest an au arătat cât de vulnerabilă este Republica Moldova în fața tendințelor tot mai pronunțate și a amenințărilor la adresa securității. Instituțiile statului, chiar dacă au reușit să facă față într-o anumită măsură, au devenint ineficiente în raport cu scheme multiple de dezinformere, manipulare și cumpărare a voturilor. Gradul de capacitare a autorităților și instituțiilor se cere a fi ridicat. Or, consolidarea eforturilor la nivel regional este un pas important și necesar, dar insuficient în condițiile în care avem un spațiu intern dezbinat și ușor influențat de dezinformare și propagandă. Faptul că amenințările la adresa securității sunt atât interne cât și externe accentuează necesitatea de creștere a rezilienței și consolidării instituționale, sociale, politice și economice.

Mulțumiri
Articolul este elaborat în contextul realizării Proiectului „Consolidarea mecanismelor socio-economice și juridice de asigurare a bunăstării și securității cetățenilor” (CONSEJ 01.05.02).

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The role of intelligent health technologies in preventive care

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Abstract
Technology has become an integral part of our daily lives. To ensure quality health services or preventive care, it is essential to implement good practices and policies adapted to new realities and technologies. This adaptation enables the healthcare system to respond more effectively to the current needs of patients and to promote innovation in service delivery. The main aim of our work is to identify projects at European and national level regarding the digitization of medical services, highlighting smart technologies that bring significant benefits to healthcare, optimizing patient monitoring and providing personalized treatment through artificial intelligence and telemedicine. Based on best practices revealed by innovative hubs like SHIFT HUB, a European project, financed by Horizon Europe with the aim of establishing a collaboration hub for smart medical technologies and innovation, by creating a network of relevant actors from the national and European health systems, we will demonstrate that these solutions reduce pressure on health systems and improve chronic disease management, integrate digital education and modern methods, increasing patient engagement. SHIFT HUB introduces innovative methods and a gamified e-learning experience to improve digital literacy and encourage citizen and patient interaction with new health technologies. In this paper, we will present the benefits this project has for patients but also for ordinary citizens and how a technical pilot platform can help society evolve.

Keywords: open innovation, smart health technology, digital literacy.

1. Introduction
Technology has become an integral part of our daily lives, playing a crucial role in the medical field, with a profound impact on how patient care is delivered. When we are faced with unclear information, we rely on search engines to find quick answers.

For example, telemedicine has revolutionized the accessibility of health services, allowing patients to consult doctors without physically moving. This is important because many people cannot get to hospitals, either due to distance or health reasons. Thus, waiting time and exposure to infections are reduced, patients can chat (via digital platforms) with their doctors, receive prescriptions and monitor health status, all from the comfort of their own home. Challenges persist, as not all patients have access to technology, which can create inequalities.

The use of artificial intelligence (AI) in personalized diagnostics and treatments is constantly expanding. As a result, doctors can analyze patient data faster and more efficiently. Robotics are also playing an increasingly important role in surgery, allowing for more precise and less invasive procedures. However, there are challenges related to the integration of these technologies, as the confidentiality of patient data must be ensured. In conclusion, technology is transforming the medical field in an innovative way, but it requires constant attention to address emerging problems.

Technology is also important in the way diseases are diagnosed, treated and managed. Technological innovations have led to improvements in the efficiency (and accuracy) of medical care, having a significant impact on patient outcomes. A fundamental aspect of technology in medicine is the development of advanced diagnostic equipment such as computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound. These technologies allow doctors to obtain detailed images of internal organs, facilitating the early diagnosis of diseases. Also, laboratory technology, such as genetic analyzes and biomarker tests, helps to personalize treatments and identify genetic predispositions.

In addition, information and communication technologies improve the management of medical data, electronic patient record systems facilitate rapid access to relevant information and improve coordination between specialists. Big data analysis allows the identification of epidemiological trends and the development of more efficient intervention strategies.

2. Literature review

The literature highlights the contribution and impact of smart health technologies in improving prevention and medical care, as well as the importance of a collaborative network of actors. These technologies, including artificial intelligence (AI), digital infrastructures and platforms, enable continuous health monitoring and the use of data to personalize treatments.

Eric Topol, recognized as one of the most innovative thinkers in the field of digital medicine, offers a transformative vision of the future of healthcare in The Patient Will See You Now. He argues that mobile technology and artificial intelligence are democratizing medicine, transferring control from an impersonal and expensive system to patients, who can monitor their health, obtain diagnoses, and access effective treatments via smartphones at significantly reduced costs [1].

This profound change, which Topol calls medicine's "Gutenberg moment," paves the way for more accessible, collaborative, and real-time data-driven healthcare. While ethical challenges and institutional resistance are inevitable, the author demonstrates how digitization can deliver more humane, affordable, and personalized care essential for anyone aspiring to a better medical future.

In The Second Machine Age, Erik Brynjolfsson and Andrew McAfee examine how digital technologies are revolutionizing the economy and society, offering enormous benefits, such as advanced infrastructure and unlimited access to cultural resources, but also significant challenges, such as the disappearance of traditional jobs and increasing economic inequality. The authors propose strategic solutions to address these transformations, including adapting education to the demands of the new economy, integrating digital technologies with human creativity, and implementing innovative policies that support a just economic transition [2].

"History began when humans invented gods, and it will end when humans become gods." In Homo Deus: A Brief History of Tomorrow, Yuval Noah Harari examines the impact of advanced technologies, such as bioengineering and artificial intelligence, on extending life,

improving health, and transforming humanity. The author explores provocative visions of the future of humanity, highlighting aspirations to transcend natural limits and become creators of artificial life, suggesting that this transition to Homo Deus represents the next step in the evolution of our species [3].

A European Commission report details the use of AI for early detection of chronic diseases, optimizing workflows and reducing medical errors. These solutions are essential to meet the needs of an aging population, with these technologies enabling continuous data collection, supporting chronic disease prevention and reducing hospitalization costs. The European Commission's "Artificial Intelligence for Health" report describes the potential of AI in preventive care, noting the implementation of predictive algorithms [4].

However, challenges related to data interoperability and privacy protection remain critical for effective implementation [5].

In the same report of the European Commission, it is mentioned that Romania has taken important steps towards the digitization of health, but challenges related to IT infrastructure and data interoperability persist [5]. Electronic medical records have been partially implemented, but their expansion is crucial to ensure efficient access to data and improve early diagnosis [6].

Big data and artificial intelligence are essential tools in predictive analytics and health risk modeling. Studies show that algorithms can identify subtle patterns associated with cardiovascular risk or diabetes before symptoms become obvious [7]. These technologies improve medical decision-making and contribute to the personalization of treatments.

In addition, a report by the World Health Organization emphasizes the need to develop digital education among patients to reduce inequalities in access to technology.

Platforms such as MyHealth@EU provide cross-border access to medical data, facilitating better coordination between Member States [8]. Germany's Digital Health 2025 looks at the adoption of smart technologies at the national level, including electronic patient records and telemedicine initiatives [9]. Germany remains a European leader in integrating these technologies to improve prevention and access to care [6], [10]. Broad adoption of smart technologies requires close collaboration between governments, healthcare providers and technology developers. Investments in digital infrastructure and policies to reduce digital divides are critical to realizing the long-term benefits.

At the national level, a report by the Ministry of Health emphasizes that the use of wearable devices, such as heart rate monitors or blood glucose sensors, contributes to the continuous monitoring of patients' health, reducing the incidence of chronic diseases and the costs of hospitalizations [7]. These technologies are supported by public-private partnerships, such as those initiated within the "eHealth Romania" project [4], [11].

AI-based platforms are being used on a pilot basis in hospitals in Bucharest to analyze medical images, such as mammograms, improving cancer diagnosis [10]. Also, European

projects such as "Horizon Europe" include Romania in initiatives for cross-border sharing of medical data, facilitating research and personalized prevention [12].

Creating a collaborative ecosystem based on open innovation requires the involvement of governments, private companies and non-governmental organizations. Successful models, such as the Estonian one, demonstrate how interoperability and accessibility can be achieved through concerted policies and investments. A successful example for Romania is the national telemedicine program for rural areas, which demonstrates how technology can reduce access disparities [13].

These papers illustrate the contribution of smart technologies to preventive care through: early detection of risks, personalization of treatments and improved access to medical services. However, the literature highlights challenges such as inequalities in access and technological barriers. A key future direction remains the creation of a political and technological framework that would favor the full integration of these solutions into the health systems of the European Union. The literature highlights the benefits of open collaboration between health system actors, including cost reduction and efficiency gains. However, success depends on political and financial support and concrete measures to improve equal access to technologies and digital education among patients.

3. Exploration of digital resources. Relevant projects identified on the Internet
This article will highlight the importance of projects at the European and national level regarding the digitization of medical services.

The projects considered aim to improve digital health in Europe, supporting digital transformation and creating interoperable frameworks. They involve transnational partnerships between EU member states. The emphasis is on easy access to medical data and the exchange of information between citizens, professionals and researchers. The initiatives promote a patient-centered approach, improving access to personal data and health services. Technology is used to develop innovative and adaptable solutions in the field of healthcare.

Fig. 1. Digital Health
Source: https://commercetools.com/solutions/for-healthcare?

Here are four European projects focused on smart health technologies and collaborative networks promoting open innovation:

1. The Smart4Health project, running between 2019 and 2023, aimed to establish a European digital health framework focused on patient-centred healthcare. Involving Portugal, Germany and other EU countries, the project developed interoperable tools that enable citizens to manage their health data, increasing patient engagement in EU health systems and creating a basis for cross-border exchange of health data [14].

2. A project active from 2021 to 2023, TEHDAS (Towards European Health Data Space), brought together countries such as Finland, Belgium and Spain to create frameworks for sharing health data across Europe. The project promoted collaboration between policy makers, technology providers and healthcare institutions to support health data research and innovation across EU borders [15].

3. Digital Health Europe discusses industry best practices for protecting sensitive healthcare data, including HIPAA compliance. The predecessor of the GDPR (General Data Protection Regulation, EU, 2016) is HIPAA (The Health Insurance Portability and Accountability Act, US, 1996). GDPR has a much broader focus and legal implications, so businesses whose operations are compliant with HIPAA cannot assume compliance with the GDPR and vice versa. Security is at the heart of both regulations, but there are distinct differences between them. From 2018 to 2020, this initiative involved EU nations such as Austria, Italy and Poland, providing support for the digital transformation of healthcare through funding, technical support and stakeholder networking. A key outcome was the development of best practices for data sharing and the digitalisation of healthcare across Europe. [16]

4. As specified in a recent report, the EU4Health programme, ongoing from 2021, emphasizes transnational collaboration to improve digital capabilities in health. In countries such as France, Greece and the Netherlands, it encourages networks to share data standards and smart health technologies. Key outcomes include frameworks for digital health solutions that can adapt to the unique needs of different EU Member States [17].

These projects reflect Europe’s commitment to integrating smart technologies into health systems through a collaborative and open innovation approach. They address data interoperability, patient engagement, and provide resources for health technology stakeholders.

In Romania, we have identified projects that contribute to the consolidation of digital capacities and integration into European networks, reducing inequalities through expanded access to medical resources and technologies.

In recent years, Romania has also been involved in a few projects. These projects not only improve Romania's digital health landscape, but also align it with the EU's digital health transformation goals, contributing to a more cohesive and innovative health ecosystem.

1. According to the EU Funding and Tenders Portal, Smart Health Cluster Romania promotes research and innovation by connecting technology providers, health organizations and the IT industry, providing resources for investments and the development of digital health solutions. The cluster organizes hackathons, supports the financing of medical technologies and aims to create an innovation ecosystem aligned with EU strategies. Also, at the National Conference for the Digitalization of the Medical Sector (Bucharest, 2022), the aim was to develop a resilient ecosystem of innovation in the field of health, stimulating Romania's alignment with the EU's broader strategies in the field of health technology [18].

2. The EDIH Digital Innovation Zone (2023-2025), led by the "Gheorghe Asachi" Technical University in Iasi, supports digitization in health through testing, training and networking. eDIH-DIZ is a consortium of 9 partners covering North-East Romania and aims to support the successful and sustainable digital and green transformation of the region by strengthening the capabilities of the only fully operational DIH Digital Innovation Zone in the region. The expected results include the strengthening of digital skills, advanced medical infrastructures and Romania's integration into European networks [19].

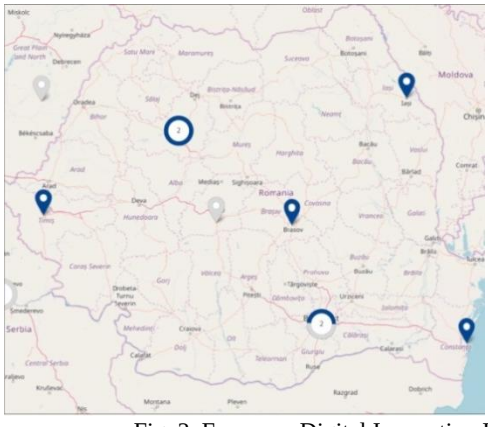

Fig. 2. European Digital Innovation Hubs (EDIH) - Romania
Source: https://european-digital-innovation-hubs.ec.europa.eu/edih-catalogue

3. SHIFT HUB is a European project, funded by Horizon Europe with the aim of establishing a Hub of collaboration for smart medical technologies and innovation, by creating a network of relevant actors from national and European healthcare systems. Part of a consortium with 12 members from 7 countries, including Romania, the project aims to create a network of relevant actors in the national and European health systems. SHIFT HUB aims to be a catalyst for positive change; inspiring individuals and organizations to contribute to a fairer and more sustainable future [20].

4. SHIFT HUB - an innovation center for smart medical technologies. SHIFT HUB is an ambitious European project, carried out between January 1, 2023 and December 31, 2025, under the auspices of Horizon Europe, with a funding of 2 million euros. The first face-to-face meeting was in Stuttgart on 30 and 31 March 2023, and strategies for the coming months were developed in various workshops. In the first year of the project, the main focus

was on building the community, but also developing the first technical solutions. Its main goal is to create an innovative hub dedicated to smart medical technologies and promoting healthcare collaboration. The project gathers 12 partners from 7 countries (Belgium, Germany, France, Greece, Italy, Portugal, Romania), each bringing a valuable contribution to the development of the network of relevant actors in the national and European health systems. Within the SHIFT HUB, modern methodologies are introduced such as "living labs", which allow users to test and validate technological solutions, and gamified e-learning programs aimed at increasing digital literacy [20]. Through these methods, citizens and patients are encouraged to interact more actively with new medical technologies. SHIFT HUB's collaborative structure, based on cooperation between universities, NGOs, government agencies, private companies and other entities, ensures the implementation of innovative and sustainable solutions.

Fig. 3.SHIFT HUB
Source: https://shift-hub.eu/

4.1. Strategic partnerships for the success of SHIFT HUB

The team behind SHIFT HUB is made up of a diverse consortium of partners who contribute with expertise and various resources. Universities provide academic support and training for innovators, while NGOs facilitate the connection between the project and communities, bringing social and environmental issues into discussion. Private companies play a key role in providing financial resources and business know-how, and startups contribute innovative ideas adapted to current needs. Government agencies create the necessary policy framework for collaboration, and research centers support the project through market studies and strategic analysis. In addition, the involvement of investment funds and sustainability experts brings a global and sustainable dimension to the project. Local communities and technical education institutions also play an important role, ensuring the relevance of the solutions developed and providing technical training. This collaborative ecosystem has the potential to turn environmental and social challenges into opportunities for innovation and progress [20].

4.2. Center for health innovation, monitoring and future technologies

Smart technologies are revolutionizing the way patients and doctors interact, facilitating real-time data exchange and improving health monitoring. The Smart Health technologies in SHIFT HUB have the potential to greatly improve the healthcare system, but their

widespread implementation remains difficult due to significant obstacles. The development of quality digital applications depends on a solid database, but the collection and management of personal health data in the EU faces difficulties, especially in a cross-border context. In addition, the "digital divide" negatively affects the elderly and those with low incomes, who either do not have the necessary skills to use technology or cannot afford access to these smart solutions [20]. The use of telemedicine-based solutions allows adjusting treatments without requiring physical presence, thus reducing the burden on patients and medical systems. This proactive approach encourages the prevention and early management of health problems, increasing the efficiency of medical care. In addition, adopting habits guided by technology and artificial intelligence can transform the way people manage their health in the long term. Developing these new habits requires consistency, curiosity about new technologies, and openness to suggestions from AI systems. As technology takes over the more complex tasks of health monitoring, individuals can focus their energy on the activities that bring them joy, without compromising attention to their well-being. This model offers tremendous opportunities to delay or prevent the onset of health problems, promoting a more balanced and sustainable lifestyle.

4.3. Innovation and education through gamified technology

A central element of SHIFT HUB is its smart health app that combines gamified education with medical prevention. The digital platform includes games that address five major health issues: disease prevention, chronic disease management, healthy lifestyle promotion, mental health and cancer prevention. Games such as the Card Association Game and the Drag & Drop Game educate users about disease prevention and chronic disease management, while the Basket Collection promotes cardiovascular prevention. Quiz Game explores mental health and a simulation game improves knowledge about cancer prevention. This digital literacy effort in a relaxed and interactive way brings about a positive impact on public health. SHIFT HUB not only provides access to resources and mentorship for social entrepreneurs, but also creates a vibrant community that collaborates to create meaningful change. Thus, SHIFT HUB becomes a catalyst for social and ecological transformation, inspiring and mobilizing individuals and organizations to contribute to a fairer and more sustainable future [20].

4.4. Benefits and challenges in implementing SHIFT HUB

SHIFT HUB provides a unique platform for fostering innovation and developing sustainable solutions that address social and environmental challenges. Among the major benefits is the creation of a cross-sector collaborative environment that brings together entrepreneurs, organizations and communities. Participants gain access to diverse resources such as mentoring, infrastructure and funding, which increase their chances of success in their initiatives. However, project implementation also comes with significant challenges. Limited financial resources can delay or even block the development of some promising initiatives. At the same time, resistance to change on the part of certain communities or organizations can complicate the adoption of innovative solutions. Also, coordination between stakeholders with varying objectives and the lack of necessary expertise are other obstacles that can affect the success of the project. To overcome these impediments, SHIFT HUB could implement a continuous training program, focused on developing the necessary

skills for project management, fundraising and marketing. Thus, not only will the initiatives' chances of success be maximized, but the community created around the project will also be strengthened, amplifying the social and ecological impact [20].

Fig.4 SHIFT HUB Events
Source: https://shift-hub.eu/events/

Discussions

Technological progress in the field of medical services has outlined new perspectives on how health can be monitored, treated and managed. However, this advance involves not only opportunities, but also challenges that require solutions adapted to the national context. In the case of Romania, a successful model for the future is based on adapting global technologies to local needs and constraints, promoting close collaboration between authorities, medical institutions and the private sector.

Extensive digitization, development and full implementation of electronic medical records at the national level. This would facilitate quick access to patient data, reducing diagnosis and treatment times. Projects such as MyHealth@EU or cross-border collaborations within European programs provide relevant examples.

Reducing inequalities in access to technology is essential and part of the digital education agenda. Promoting digital literacy among the population, through programs dedicated to both medical personnel and patients, can contribute to the effective use of digital platforms and wearable devices for health monitoring.

The experiences within the SHIFT HUB or Smart Health Cluster projects, as public-private partnerships, demonstrate the importance of collaboration between governments, private companies and non-governmental organizations for the development of innovative solutions. Romania can develop similar innovation centers, with European support, to implement advanced technologies such as artificial intelligence (AI) and big data analysis.

To maximize the benefits of technology, standardization of data formats and compliance with regulations on the protection of personal information are critical. The example of

Estonia, a European leader in e-health, highlights the importance of interoperability for the efficient exchange of medical information.

To respond to Romania's specifics, the following directions are recommended:
Existing programs, like those in rural areas, must be developed and integrated with other digital solutions. Thus, telemedicine can become a viable alternative for areas with limited access to medical services.

Encouraging the use of sensors and health monitoring devices at home can reduce the incidence of chronic conditions and the costs associated with hospitalization.

Investments in IT infrastructure, such as dedicated servers and secure data networks, are fundamental for the expansion and efficient use of electronic health records.

Pilot projects, such as those carried out in Bucharest for the analysis of medical images through AI, can be replicated at the national level to test and expand the use of leading technologies.

The integration of technologies in medical services is not only an opportunity for modernization, but also an essential step to meet the growing needs of the population. However, success depends on adopting a well-structured framework that promotes equal access and ensures data privacy. In Romania, adopting a model based on collaboration, digital education and innovation can transform the medical system into a more efficient and oriented.

5. Conclusions

At the European level, initiatives such as TEHDAS, EU4Health and Smart4Health support digitalization, data interoperability and the reduction of inequalities, promoting collaboration and the development of a sustainable health ecosystem, the strengthening of digital skills and advanced infrastructure in the health sector and of course, the integration of Romania into European digital health networks.

To date, the SHIFT-HUB consortium has developed patient-centric services, focusing on creating a diverse community, including technology startups, universities, research institutes, physicians and patients/citizens. The results obtained include dedicated applications for five selected pathologies and educational games to promote prevention.

SHIFT-HUB organized impact events, such as two international conferences on SMART HEALTH innovation, Demo Days for the presentation of applications, Living Labs and workshops focused on accessing European funding.

To respond to the need to improve the digital skills of health professionals and the general public, the consortium created the SHIFT-HUB Digital Catalog, an online platform that offers 189 resources structured in 15 thematic categories. They cover topics such as artificial intelligence, data science, cyber security and smart health applications, targeting

diverse groups: healthcare professionals, patients, entrepreneurs, SMEs and students, contributing to the development of digital skills.

The project team continues to analyze the needs of the target groups in order to design services adapted to them. In the coming months, until the end of 2024, efforts will focus on maximizing the impact of SHIFT-HUB resources, through intensive collaboration between partners and the active involvement of all stakeholders.

SHIFT HUB and smart technologies represent essential pillars for the transformation of health and society, emphasizing innovation, collaboration and sustainability. The use of telemedicine and artificial intelligence-based solutions improves health monitoring, reducing the burden on patients and medical systems. This is very well highlighted in the online events organized, with partners actively participating nationally and internationally to promote the mission, activities and services offered. At the same time, SHIFT HUB creates an ecosystem conducive to developing sustainable solutions, addressing social and environmental challenges. However, success depends on managing obstacles such as limited resources and lack of expertise.

Through mentorship and ongoing training, the project can become a catalyst for positive change, promoting a more equitable and healthy future.

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New generations of students, new school creators

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Abstract
Young people today grow up with technology, they use it every day and do not know a world without it. Mostof our students know how to use ICT tools for their purposes. Schools must help them to use these tools for learning as much as to satisfy their curiosity. Therefore, we are beginning to see the development of another category of tools - web-based educational applications. However, technology alone cannot solve every problem in education. Some issues are unsolvable, but the application of technology can sometimes sufficiently help. It sounds rather frankly, does it not? New "types" of students represent a generation born with a computer mouse in hand and a computer screen as a window to the world. They are also known as Homo Zappiens. The name Homo Zappiens is derived from the Latin word "homo" (man) and the onomatopoeia of brandishing laser weapons "zap-zap-zap", or of changing TV channels with the remote control. Homo Zappiens plays computer games, communicates 24/7 with the help of various tools and software, creates virtual friendships with fb friends, preferring the Internet and mobile phones to the printed media. Homo Zappiens likes to play computer games in which there are no winners and losers, which are without a beginning or end, and where it is possible to continuously change the rules of the game. Digital technology has become a part of education and it influences the needs of today's students, curricula, and the overall organizational structure of educational institutions. What these new "types" of students need is a more flexible educational system. The process of learning belongs to them and they become clients to be served. Therefore, flexibility must be reflected in the learning objectives and tasks, content, strategies, methods and forms of work, verification of knowledge, technology and media, and time and study environment. This paper discusses the new "types" of students who study in a manner quite different from previous generations. Due to the rapid development of technology new types of students who learn a completely different way have been created. They are able to perform multiple tasks simultaneously. Thus, schools must adapt to the discontinuity of the modern era which makes traditionally oriented educational concept rather unstable.

Key words: reforms, students, new “types of students“, technology, schools.

1. Introduction
All educational reforms so far have been related to external changes including reforms of curricula, change in the length of schooling, changes in the organization of schools, changes in educational goals and tasks, etc. The requirements set by the strategies for reforming the teaching process, the forms and methods as well as the position of pupils/students in the Republic Macedonia, are joined in the proposals for modernizing teaching, of which the most frequent are the following: application of active forms and methods of work, placing students in situations in which they observe, analyze, arrange, synthesize, conclude, generalize, investigate, and use various sources of knowledge, problem solving, etc. Since the very beginning of school it was and has remained the subject of many studies and it seems that the fundamental issue in these studies has been how to organize the school. The search for the answer to the question how to best organize schools necessarily includes the search for the answer to the question: What is a human being? A human being (student) is a complex being, not only a being of culture (homo culturalis), (homo faber) a being who creates, a being who thinks (homo sapiens), a being who teaches/learns (educator - educans), but all of them together with a potential for something more. By reducing the human being to one or more than one dimensions, education is expected to create a usable product. Most schools typically see a student as a homo sapiens and their "thinkingness" is

measured by the amount of stored or reproduced information. In accordance with that understanding, the efficiency of a school is measured by the "cognitive achievement" on tests. For this reason, school reforms often move from one extreme to another (from "reform makeup that means ‘more of the same’, to "psycho-social issues") while constantly losing sight of a complete human being.

Dutchman Wim Veen has been researching digital natives for nearly twenty years, those individuals who have been born and raised in the midst of these hypermodern times and the global screen (as Lipovetsky calls them). Veen has coined a provocative and playful term to refer to these contemporary subjects: Homo Zappiens - which has raised more than one hackle, because academia and a sense of humor do not usually go hand in hand.

Zappiens, hence his name, is that individual who has grown up in an environment characterized by discontinuous information: when he watches television he frantically zaps through the hundreds of channels offered by cable, chats, listens to music, sends text messages, plays online video games and does (or tries to do in the shortest time possible) his schoolwork all at the same time. And, apparently - although it may seem so to us from the outside - he does not usually sink in this Maelstrom of chaotic information in which he is constantly submerged.

According to Veen, the so called Homo Zappiens is endowed with a number of skills that allow him to deal with technology as if the entire world were a gigantic technological construct: they do not read in an orderly fashion from left to right or line by line, but rather their reading is more like scanning, a rapid vertical reading where they read texts, images, colours, textures and hyperlinks at the same time; they do not follow instructions or check manuals, but rather they approach the information that is offered to them in torrents on the screen in an intuitive way and almost always they know where to click to continue reading. Many may complain that Zappiens do not read or that they read less and less, to which Veen responds that they do read, they read a lot, but they just read differently and about other reading formats; they feel like fish in water jumping between screens, dealing with mobile phones, video game controllers, computer mouse, electronic tablets and the TV remote control. That is their world and, given the hectic direction things are taking, any person who does not develop these skills to deal with and understand technology would be left in a clear state of disability when it comes to interacting with the life that has been handed to them.

However, at the end of the last and the beginning of the new millennium, changes in technology created the effect of concentric circles on the water surface, thereby changing the fundamental and long ingrained attitudes. Some areas are highly susceptible to change, while others are more conservative. In no other area is this more visible than in the process of education and learning. In real life in today's schools the technological revolution has changed the student under the influence of the dynamic environment and he/she has been transformed into a "new type of student." Besides creating new environments and challenges, technology affects our brain and even modifies it. Reviewing the basic understanding of neurology [1], points out that "plasticity refers to the brain's ability to change." Our brains are constantly changing, developing, and they need to respond to

transformations in our environment and the tools we use. Not only do these new tools require adaptation on the part of the user, but they are also changing the way of his/her thinking.

The students of today are radically changed. They did not only change their clothes and style compared to previous ones, but they think and process information in a way completely different from previous generations. Current students have experiences that are very different from previous ones. Different kinds of experiences lead to changes in brain structures and it is very likely that the brains of students physiologically changed and are different from those of previous generations, and all this is due to the manner and conditions in which they grew up [2]. Whether this is literally the case or not, we are convinced that the way they process information has radically changed [3]. Believes that "new" students appear in the educational system who have formed under the influence of new developments in the world of new technologies. These students are not passive consumers of educational resources of knowledge. At the end of the 80s of the last century children were born, grew up and developed in an advanced technological environment. Today's students, from kindergarten to university, are the first generation that has grown up with digital technology, a computer mouse in hand, TV remote control, mobile phone, iPod and other electronic devices for communication and entertainment. This same generation is the expected result of the inclusion of digital technologies in everyday life, where all the technological advantages are regularly used for easier communication, learning or playing. Many tools of the digital age, such as computer games, the Internet, e-mail, instant messenger, wikis and blogs are an integral part of their lives [4]. The usage of the mass media is declining while online communication with peers, searching for information and entertainment on the Internet, are becoming increasingly popular among young generations [5]. New tools - new schools, new ICT tools are changing the way people, including our students, communicate with the world. The challenges of the new millennium require that students be more adaptable and analytical, and possess skills for recognizing which are the best tools in the environment that is rapidly changing. Have schools changed? Some have, but some are still adjusting. In order to be new, a school must create new ways of teaching and learning, and introduce the use of new methods in the teaching process. We should find a way to successfully help students in the 21st century – both in work and in play, and in all other aspects of life in a world that promises nothing else but change.

Young people today grow up with technology, they use it every day and do not know a world without it. Most of our students know how to use ICT tools for their purposes. Schools must help them to use these tools for learning as much as to satisfy their curiosity. Therefore, we are beginning to see the development of another category of tools - web-based educational applications. However, technology alone cannot solve every problem in education. Some issues are unsolvable, but the application of technology can sometimes sufficiently help. It sounds rather frankly, does it not? Technology has dramatically changed the way today's generation of children (students) live. We are speaking about the generation of new "types" of students for whom personal computers, the Internet, MP3s, mobile phones, iPods, and all the "old" media, are the natural environment in which they grew up. New "types" of students represent a generation born with a computer mouse in hand and a computer screen as a window to the world [6]. They are also known as Homo

Zappiens. The term Homo Zappiens was created and publicly presented for the first time at a conference in Oslo in 2000, by the Dutch university professor Wim Veen, who had been dealing for years with the impact of ICT on education and pedagogy. The name Homo Zappiens is derived from the Latin word "homo" (man) and the onomatopoeia of brandishing laser weapons "zap-zap-zap", or of changing TV channels with the remote control. Homo Zappiens plays computer games, communicates 24/7 with the help of various tools and software, creates virtual friendships with fb friends, preferring the Internet and mobile phones to the printed media [5]. Homo Zappiens likes to play computer games in which there are no winners and losers, which are without a beginning or end, and where it is possible to continuously change the rules of the game [4]. Games require proactive players who solve problems and provide an environment in which children experiment, taking different roles. These games encourage research approach to learning since children very often begin to play even if they do not know what the ultimate goal of the game is [7]. They define theirgoals and appropriate strategies to achieve those goals. The games that do not have a limited number of participants are very popular on the network, so anyone interested can join the game and thus, through the game, a person/participant is able to communicate with people from different age groups and with different views on life. All participants in the game try to solve a variety of strategic issues through continuous interaction with each other.

Fig. 1. (a) Illustrations of a boy wearing vr headset in vibrant; (b) Illustrations of a boy wearing vr headset in vibrant.
Source: https://www.freepik.com/

By communicating with a variety of digital tools, students can take different identities thus experimenting with social roles [8]. To facilitate and speed up communication new "types" of students have even developed a new form of communication, so that their messages consist of a number of abbreviations they understand. In order to get information about something that interests them, new "types" of students first search the internet by entering keywords in a search engine (e.g. Google) or by calling their friends. Various activities are offered through wikis and blogs (video blog, photo blog, drawing, audio) so they can see each other, create, share, and comment. Easy operation with digital recordings, an abundance of simple software and free space in cyber-space have enabled the young generation to create their own custom made media world. Homo Zappiens have learned to get by in the world of information and successfully deal with information overload [4]. They are aware that there is a tremendous amount of knowledge which, with the help of technology, is quickly and easily accessible, and they build their knowledge at the time

they want to know something or when it is necessary for employment, hobby or something else. Because of this line of reasoning, the way of understanding the processes of education, the place, time and manner in which they are carried out are constantly changing, and hence the concepts and ideas of “just-in-time learning”, “learning-on-demand”, “just enough learning”, and “just for you learning” are becoming more and more current. Attitudes that see knowledge as a whole consisting of "knowing what" (explicitly) and "knowing how" (implicitly) are replaced with "knowing where".

For this new "types" of students it is very important to know where to find specific information, the way in which any information will be critically processed and placed in a wider social context and the manner in which to communicate with others in the easiest, fastest and most effective way. Through this experience the children (students) develop research approach to learning and they construct and give meaning tothe information. With the help of the research approach to learning a number of metacognitive skills that are very important in the learning process are being developed [5]. Merging of individual media characteristics or mixing of text, audio and video elements and the interactive approach to these elements makes these new "types" of student’s active creators and users of what is being offered.

We are immersed in a legitimate bombardment of information, the global screen has us literally drowning in an ocean of images, visual and acoustic stimuli of all kinds and at hyper-machine-gun speed. We are not capable of dealing with so much information, the torrent of the computer avalanche is infinitely greater than our capacity to grasp and metabolize it, so the only option we have is to become progressively more and more superficial. There is no time for reflection or contemplation, there is no space for the development of critical thinking. Stopping to think, to unite ideas, to establish links between ideas and things, taking the time to “create” in the broadest sense of the term, is something that we are also losing at breakneck speed. Artistic creation, whether narrative, poetry, essay, film, painting, sculpture and so on, in the light and rhythm of hypermodernity, would in the long run be one more of the species in clear danger of extinction. There are certainly reasons to worry, to succumb to the dark and hopeless idea that, as things are looking, things are not good and are getting worse.

Perhaps, it appears, the world without wars, tolerant, respectful of others that we have always dreamed of, can only be in the hands of that new man (Zappiens, the reader-player who lives in his game-world, give him the epithet you like best) who only wants to entertain himself and play, who does not want to bother or be bothered while he jumps superficially through that world (that of the screens, but also that of this side of existence) from which he only takes what catches his attention while ignoring everything else. That superficial, frivolous, playful and fragmented individual would then not be concerned with annihilating or segregating anyone because the other thinks or is different. The arts will die in the hands of frivolity, but also ideologies. There will be no time for Creation, but neither for Destruction.

It may be that the new man decides to use an unsuspected weapon to finally change the world, an unusual and rarely used weapon but one that has always been there: Ignoring that

which we have always considered Important. An ignorance that translates into I don't care, I don't care at all, I don't care, leave me alone because I want to do my thing, what I want is to have a good time, to entertain myself, I want to exploit my lifelong right to play with my harmless toys and there you go with your little toys and your little games.

2. New "types" of students – new school

These new "types" of students represent a generation for whom learning is a game. For them, school is a place for socializing with friends, rather than a place for learning [4]. This generation of children (students) has grown up with technology and learns from computer screens, icons, sounds, pictures and games, exploring and questioning. The expected consequence is the emergence of new ways of reasoning, nonlinear approach to learning, faster adoption of information, multi-tasking, etc. Given the above, we can say that the new "types" of students are characterized by 4 skills [5].

- Iconic skills
- Multi-tasking
- Concurrent processing of different types of information
- Nonlinear approach to learning.

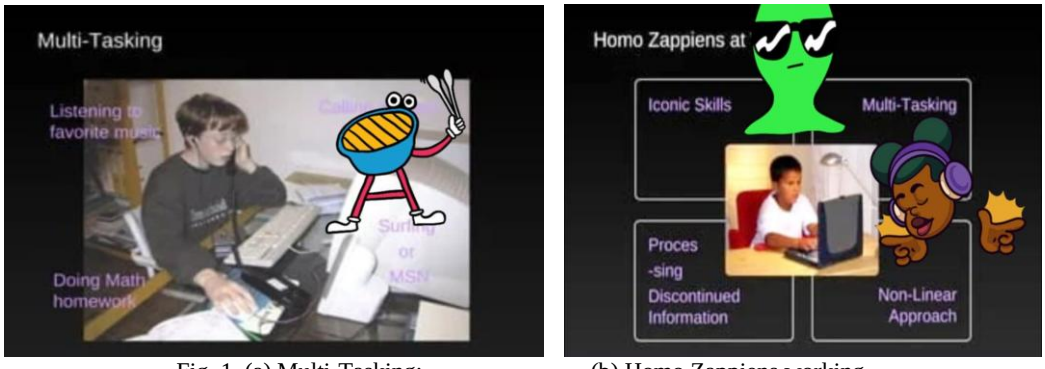

Fig. 1. (a) Multi-Tasking; (b) Homo Zappiens working.
Source: https://www.slideshare.net/HansMestrum/homo-zappiens

Today's students learn intuitively and find their way much better when surrounded by icons (Windows and the Internet). Finding their way on pages full of icons, colors, images, Flash and Java applications and sound effects is not a problem for them. Multitasking is a skill typical of the new "types" of students. The new "types" of students are accustomed to receiving and processing information very quickly and they perform several tasks simultaneously. They also prefer a nonlinear approach to learning and do not cope well when the contents are organized in a linear way, and today's schools are mostly analog and linear [4].

This "Homo Zappiens" taken to the extreme is a social autistic. He is so immersed in his virtual world that he does not notice what is happening around him, he only feels comfortable among people of his own species, with whom he has little or no real contact.
That the salvation of the world lies in such a being, I am going to say the same as you, I don't know, I don't know. I remember a movie called "War Games". It is about a child who

innocently starts a virtual game, and by mistake almost ends up in a real world war. It also terrifies me to think that, while "the good guys" prefer to voluntarily isolate themselves from reality so as not to feel their vulnerability, "the bad guys" take control of the world as in Sucker Punch.

Linear learning causes stress and lack of motivation in the new "types" of students. They learn in such a way that they themselves rearrange content so that it suits them at a particular moment, which is very different from the approach in which the teachers or the textbook always transmit the content in the same manner and order. The new "types" of students are accustomed to the hypertext which provides them with such features, as opposed to plain text.

All this is contrary to the approaches of previous generations. Previously the children learnt in a rational way, and reading was the basis of their learning. Data is soaked up one by one and worked exclusively one thing at a certain time, or developed ability to mono-requirements. They learned to work alone, laying competitive and different learning game. The data were absorbed one by one and they did exclusively one thing at one time, i.e. they developed the ability to cope with mono-requirements. They learned to work alone, have a competitive attitude and to distinguish play form learning. The way the new "types" of students access information and communicate, as already mentioned, developed completely different generic skills in children, different abilities and, consequently, new abilities for learning. The following table shows a comparison of the characteristics of Homo Sapiens and Homo Zappiens in the learning process.

Table 1. Characteristics of the new "types" of students - Homo Zappiens and Homo Sapiens (according to Prensky)

Homo Zappiens	**Homo Sapiens**
Great speed	Conventional speed
Wide attention span	Long attention span
Multitasking	Monotasking
Holistic approach to learning	Analytical approach to learning
Nonlinear approach to learning	Linear approach to learning
Iconic skills	Reading skills
Networking, Individuality, Cooperation, Competition, Activity (creation of knowledge)	Passivity (listening and reproduction)
Learning with searching for information	Learning through memorizing information
Learning through play	Learning is different from play
Learning through externalization	Learning through internalization
Using fantasy	Orientation to reality

Considering the above table, it is important to note that new "types" of students - Homo Zappiens, unlike Homo Sapiens who are fully analogous, are fully digital (multitasking), and that the learning process has evolved from individual activities of internalization of knowledge to social externalization of knowledge. Although many theories of learning emphasized the importance of social activities in the learning process long before technology started to dominate students' lives, it is with the help of technology that people

(students) become the nodes of technical and social networks. Social networks on the Internet we be described as a meeting place for communication and creation of knowledge, and social networking, which is facilitated by a variety of social software, is the main activity in the construction of knowledge. The new "types" of students are selfguiding students 'nano' students, digital thinkers, experienced communicators and creative problem-solvers, and they have developed new values as opposed to the values of the previous generation, preparing themselves for a creative and chaotic society. They want to cooperate and work in a group, they are active and easily learn through play. The new "types" of students feel they have the right to define their own interests. For them everything is available and they want to do only what interests them at a particular moment. To highlight the difference between the new generation of students and previous generations, Prensky (2001) uses the term digital natives and digital immigrants.

Students today are called digital natives because they are speakers of the digital language of computers, software and the Internet. We, who were not born into the digital world, but at some point in life have found ourselves surrounded by new technology, are called digital immigrants. A digital immigrant is socialized differently and will always remain with one foot in the past. The difference between the digital native and the digital immigrant is evident in some everyday things, for example, a digital native will not print his/her e-mail messages and will read and edit documents directly on the computer. A big problem in education is that teachers (digital immigrants) speak the language of the predigital age and teach a generation that does not understand that language, i.e. Homo Zappiens who speak an entirely different language. [9] gives a list of factors that shape the mindset of the information age, and it includes: the Internet is better than TV, the practice is more important than theory, performing multiple tasks at the same time is a way of life, and learning looks more like a Nintendo than like logic. [9] concludes that "we have to think in a way that it is necessary to transform the educational experience so that it becomes important for students of the Information Age." Many studies often point to the fact that children learn much more with the help of computer games and online communication. Despite this, many educational institutions, teachers and parents complain of today's generations and many of them believe that all these technological devices and software are a waste of time, that they have an adverse effect on children's health and lead to social isolation. Educational systems underestimate new generations and treat them as a disruption, preventing their development. Those new "types" of students are often referred to as children with attention disorder and their overload with the network is emphasized. Schools, teachers and parents complain that children today have a short range of attention (i.e. they are not able to listen to us for five minutes when we are telling them something), that they are hyperactive (e.g. they are unable to concentrate on one task or some work), they are undisciplined (i.e. they forget their textbooks and school supplies, they forget to pass on a message from teachers to their parents), and they have no respect for older people (they think the teachers and they are equals). Teachers today do not value the new qualities of the new "types" of students. Their skills are completely unfamiliar to teachers. Very often we hear teachers saying "I just cannot work with them. They are impossible in class". Teachers continuously assume that the methods, forms of work and activities available and efficient when they were students, will act as such for their present students. The new "types" of students do not pay attention to what teachers teach in comparison to all the other

things that they perceive. Teachers and parents often wonder how their children can study, listen to music and watch TV at the same time. Digital immigrants are unable to do this, because they did not exercise it during their development. Some of the critics of education, in particular of the curricula, teaching methods and the traditional approach to teaching, learning and education in general, said: "Many of our schools are good schools. The design and organization of today's schools are rooted in Taylorism.

The organizational structure is based on hierarchy, mass production, standardization, planning and control. Although the industrial era is past, today's schools still exist although they were designed 150 years ago. As such, schools were institutions appropriate for the industrial era, and today they should be seen as museums. We can say that that today's schools are readymade schools dominated by teaching oriented towards the teacher. Classrooms are organized and equipped for frontal teaching in which students sit one behind the other, and teaching is organized by the teacher who is in front of them at his desk using the board or some modern teaching technology. What Homo Zappiens need is a more flexible educational system. The learning process belongs to them and they become customers to be served. Therefore, flexibility must be reflected in the goals and tasks of learning, contents, strategies, methods and forms of work, checking knowledge, in technology and media, time and learning environments.

3. Conclusions

The role of a teacher is no longer the role of a lecturer, but the role of a leader, collaborator, organizer, researcher. Teachers are mostly, not that it is their fault, trained to deliver facts, and then check whether they are adopted. Instead of just transmitting knowledge, teachers need to create new models that will stimulate learning and learning new skills. The role of the student has also changed. The very idea that someone is a student creates passivity in advance. However, the new "types" of students have set goals and objectives for learning, they actively create knowledge from different sources of information, they collaborate and provide feedback to their peers, and they assist their teachers in adopting the new skills that students already have.

Zappiens, hence his name, are individuals who have grown up in an environment characterized by discontinuous information: when they watch television, they frantically flip through the hundreds of channels offered by cable, chat, listen to music, send text messages, play online video games and do (or try to do in the shortest time possible) their schoolwork, all at the same time. And, apparently - although it may seem so to us from the outside - they do not usually get shipwrecked in this Maelstrom of chaotic information in which they are constantly submerged.

The so called Homo Zappiens is endowed with a number of skills that allow them to deal with technology as if the entire world were a gigantic technological construct: they do not read in an orderly fashion from left to right or line by line, but their reading is more like scanning, a rapid vertical reading where they read texts, images, colors, textures and hyperlinks at the same time; They don't follow instructions or read manuals, but rather they approach the information that is offered to them in torrents on the screen in an intuitive way and - almost always - they know where to click to continue reading. Many may

complain that Zappiens doesn't read or that it reads less and less, to which that responds that they do read, that they read a lot, but they just read differently and about other reading formats; they feel like fish in water jumping between screens, dealing with mobile phones, video game controllers, computer mouse, electronic tablets and the tv remote control. That is their world and, given the hectic direction things are taking, any subject who does not develop these skills to deal with and understand technology would be left in a clear condition of disability to be able to interact with the life that has been handed to them.

It is important to note that the process of learning passes into their hands and they become responsible for their own learning.

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Smart governance and emergency management systems in Nigeria: innovations and challenges

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Abstract
In Nigeria, the integration of smart governance and advanced technologies into emergency management systems represents a transformative approach to addressing the country's recurring challenges in disaster response and management. This study explores the potential of smart governance frameworks to enhance emergency preparedness, response, and recovery through digital innovations. Key technologies, including real-time data analytics, mobile alert systems, and Geographic Information Systems (GIS), can enable swift and effective responses to crises ranging from natural disasters to health emergencies. The paper examines case studies of recent emergency management efforts in Nigeria, highlighting both successful applications of technology and areas needing improvement. Despite its promise, smart governance in Nigeria faces significant challenges, including insufficient digital infrastructure, limited funding, and low digital literacy among the population. Furthermore, the lack of coordinated policy frameworks and inter-agency collaboration hampers the seamless integration of these systems. This paper argues that overcoming these barriers requires a multi-stakeholder approach involving public institutions, private technology firms, and civil society. Additionally, fostering digital literacy and ensuring equitable access to technology are essential to building resilient communities. The findings of this research contribute to the broader discourse on the role of smart governance in emerging economies, emphasizing the necessity of adaptive and inclusive policies for sustainable emergency management. By leveraging technological advancements, Nigeria has the potential to significantly improve its emergency response capacities. However, realizing this potential depends on a strategic alignment of resources, policies, and stakeholder engagement to address the unique challenges of implementing smart governance in the Nigerian context.

Keywords: Smart governance, emergency management, Nigeria, digital technology, challenges, innovations.

1. Introduction
Smart governance has emerged as a powerful approach to modernizing public administration by integrating digital technologies that enhance decision-making, service delivery, and citizen engagement. In Nigeria, where diverse natural and human-induced emergencies from floods and epidemics to communal conflicts pose significant threats, the application of smart governance principles to emergency management systems holds immense promise. Leveraging innovations such as real-time data analytics, Geographic Information Systems (GIS), mobile alert networks, and artificial intelligence could enable Nigerian authorities to improve emergency preparedness, response, and recovery. However, the implementation of smart governance in Nigeria's emergency management framework faces numerous challenges. The country's digital infrastructure remains underdeveloped in many regions, limiting the reach and effectiveness of technologically driven solutions. Additionally, gaps in inter-agency coordination, inadequate funding, and

low levels of digital literacy further hinder the potential of smart governance to deliver robust emergency responses.

These limitations make it difficult to establish a fully integrated system that can swiftly address emergencies, provide accurate information to citizens, and enhance resilience among vulnerable communities. This paper examines both the innovations and the obstacles in adopting smart governance for emergency management in Nigeria. Thus, by analyzing some existing frameworks and case studies of recent disaster response efforts, this study aims to identify key factors that can strengthen the role of technology in Nigeria's emergency management landscape. The findings provide insights into how policy reform, public-private partnerships, and community-based initiatives can contribute to building an adaptable, inclusive, and effective emergency management system. Ultimately, this research underscores the need for a multi-faceted approach that addresses technological, infrastructural, and policy-related barriers to realize the full potential of smart governance in enhancing Nigeria's resilience to emergencies.

2. Background on smart governance and emergency management

Smart governance represents the integration of technology, data, and innovative practices to enhance decision-making, efficiency, and public service delivery. It prioritizes collaboration among stakeholders, transparency, and citizen-centric approaches, often leveraging tools such as artificial intelligence (AI), big data, the Internet of Things (I.T), and mobile technologies. Within the context of emergency management, smart governance plays a critical role in improving the ability of governments and organizations to anticipate, prepare for, respond to, and recover from crises effectively. Oluwole argues that:

Emergency management involves coordinated efforts to mitigate, respond to, and recover from natural disasters, health emergencies, and other crises. Traditional approaches to emergency management in many developing nations, including Nigeria, have been hindered by inefficiencies, lack of data, and limited infrastructure. Smart governance seeks to address these challenges by integrating real-time data, predictive analytics, and automated systems into emergency response frameworks (65).

In Nigeria, the need for smart governance in emergency management is evident, given the country’s vulnerability to flooding, epidemics, insurgencies, and other crises. However, the implementation of such systems faces challenges such as inadequate infrastructure, low digital literacy, and bureaucratic hurdles. Despite these obstacles, adopting smart governance holds significant potential to transform emergency management, strengthen resilience, and enhance national development.

3. The importance of technology in governance and emergency response

Technology plays a pivotal role in enhancing governance and emergency response systems, enabling governments to deliver services more efficiently, make informed decisions, and respond effectively to crises. In governance, technology facilitates transparency, accountability, and citizen engagement. Digital platforms enable real-time communication between governments and citizens, ensuring that policies and programs address the public’s needs [1]. Tools such as big data and artificial intelligence (AI) allow governments to

analyze trends, predict challenges, and implement evidence-based solutions, fostering efficiency and reducing bureaucracy. Balogun further argue that:

In emergency response, technology is essential for improving preparedness, early warning systems, and disaster management. For instance, the Internet of Things (I.T) enables the collection of real-time data from sensors placed in vulnerable areas, such as flood-prone zones, allowing for timely alerts and swift evacuation measures. Geographic Information Systems (GIS) support the mapping of disaster-prone areas, while AI and predictive analytics enhance decision-making during emergencies (155).

Thus, in countries like Nigeria, where natural disasters, health emergencies, and security challenges are prevalent, technology significantly improves coordination and resource allocation. Mobile platforms facilitate mass communication, while drones and satellite imagery aid in search and rescue missions [2]. However, challenges such as inadequate infrastructure, digital illiteracy, and cybersecurity threats must be addressed to maximize the potential of technology. Despite these hurdles, the integration of technology remains indispensable for fostering resilient governance and efficient emergency management systems.

4. Overview of challenges in Nigeria's current emergency management system

Nigeria's emergency management system faces significant challenges that hinder its ability to respond effectively to crises. These challenges are rooted in a combination of inadequate infrastructure, poor coordination, insufficient funding, and a lack of technological integration, all of which compromise the system’s efficiency and reliability. According to Adeoye, and Bola:

One of the major issues is the absence of adequate infrastructure. Many regions in Nigeria, particularly rural areas, lack the necessary facilities to support disaster preparedness and response, such as emergency shelters, communication networks, and transportation systems (92).

This infrastructural deficit limits timely interventions during emergencies, leaving many communities vulnerable to the devastating impacts of crises like floods, insurgencies, and epidemics. Thus, another critical challenge is the poor coordination among agencies responsible for emergency management. In Okoro’s words:

The overlapping roles and responsibilities of institutions such as the National Emergency Management Agency (NEMA) and State Emergency Management Agencies (SEMA’s) often lead to confusion and delays in response efforts. This is further exacerbated by weak collaboration with local governments and community-based organizations, which are crucial for ground-level interventions (54).

Insufficient funding also hampers emergency management in Nigeria. Budgetary allocations to disaster preparedness and response are often inadequate, resulting in a lack of essential resources, such as medical supplies, rescue equipment, and training programs for emergency responders. Following Okoro’s position above, Yusuf argues that:

The limited integration of technology into the emergency management framework further compounds the problem. Early warning systems, real-time data analytics, and communication platforms are either underutilized or unavailable, leaving authorities ill-equipped to anticipate and mitigate disasters (167).

Additionally, Yusuf is of the opinion that, the low levels of digital literacy among citizens and officials restrict the effective use of available technology. Finally, in addressing these challenges requires a holistic approach, including investments in infrastructure, capacity building, technological integration, and fostering inter-agency collaboration. Without these reforms, Nigeria's emergency management system will continue to struggle in effectively protecting lives and property during crises.

5. The concept of smart governance and its application globally

Smart governance refers to the use of innovative technologies, data-driven decision-making, and citizen-centered approaches to enhance the efficiency, transparency, and inclusiveness of governance processes. It integrates tools such as artificial intelligence (AI), big data, blockchain, and the Internet of Things (I.T) to optimize service delivery, foster accountability, and promote sustainable development [3]. This concept represents a paradigm shift from traditional bureaucratic governance to a more participatory and technology-driven model, aligning with the needs of modern societies. Mohammed stress further that:

Globally, the application of smart governance has transformed how governments interact with citizens and address complex challenges. In countries such as Estonia, smart governance has been achieved through e-governance initiatives, enabling citizens to access services like tax filings, voting, and healthcare online (47).

For him, these digital platforms not only enhance service delivery but also improve transparency by minimizing corruption. Just like Mohammed have argued above, Olufemi draw an example that:

In Singapore, the use of data analytics and I.T has streamlined urban management, particularly in areas such as transportation, waste management, and public safety. Smart governance here ensures real-time monitoring and decision-making to address urban challenges efficiently Similarly, Finland has integrated blockchain technology in governance systems to enhance data security and trust in public services (68).

For Olufemi, in emergency management, countries like Japan employ smart governance tools to mitigate the impacts of natural disasters. Predictive models, early warning systems, and disaster management apps enable proactive responses to emergencies, saving lives and minimizing property damage. However, the global adoption of smart governance faces challenges, including data privacy concerns, digital inequality, and resistance to technological change. Despite these hurdles, the concept continues to evolve, driven by the demand for resilient and adaptive governance systems. Smart governance not only improves public administration but also fosters sustainable development and societal progress on a global scale.

7. An overview of emergency management frameworks in a smart city

Emergency management frameworks in a smart city leverage advanced technologies, data-driven systems, and integrated processes to enhance the efficiency and effectiveness of disaster preparedness, response, mitigation, and recovery. According to Akinola, the incorporation of technologies such as artificial intelligence (AI), the Internet of Things (I.T), big data analytics, and cloud computing enables smart cities to anticipate, monitor, and manage emergencies in real time, ensuring better outcomes for urban populations. He argues that:

In a smart city framework, the mitigation phase focuses on using predictive analytics and AI models to identify potential hazards and develop strategies to reduce risks. For instance, I.T sensors can monitor environmental conditions such as air quality, water levels, and seismic activities, providing early warnings about natural disasters like floods or earthquakes [2].

In his opinion, during the preparedness phase, smart cities integrate digital tools for emergency planning, citizen education, and resource allocation. Mobile apps, public alert systems, and virtual simulations prepare residents and emergency responders for potential crises, ensuring readiness across all stakeholders. The response phase in a smart city emphasizes speed, coordination, and resource optimization. Okoro also argue that I.T devices and connected platforms enable real-time monitoring of incidents, such as fires, accidents, or health emergencies. Drones and robotic systems can assist in search and rescue operations, while AI-driven platforms help authorities prioritize actions based on situational analysis. Smart transportation systems reroute traffic for emergency vehicles, minimizing delays (65-66).

The recovery phase utilizes data analytics to assess damage, coordinate rebuilding efforts, and provide timely support to affected populations. Blockchain technology ensures transparent allocation of funds and resources, while digital platforms streamline communication between authorities and residents. Finally, it could be stated that globally that; smart cities like Singapore, Amsterdam, and Dubai have implemented innovative emergency management frameworks. Singapore, for instance, uses AI and I.T for flood monitoring, while Amsterdam integrates data from social media to track real-time emergencies [4]. Despite these advancements, challenges such as data security, technological inequality, and resource limitations persist. Addressing these gaps is essential to fully realize the potential of emergency management frameworks in smart cities.

Relevance of technology in emergency response and crisis management

Technology has revolutionized emergency response and crisis management, making it faster, more efficient, and better coordinated. Its integration across various stages of crisis management preparedness, response, recovery, and mitigation ensures that governments and organizations can save lives, reduce damage, and restore order effectively. Thus, in the preparedness phase, technology enables early warning systems and predictive analytics [5]. Tools like Geographic Information Systems (GIS) and remote sensing allow for risk mapping and hazard monitoring, while I.T devices collect real-time data from vulnerable areas, ensuring timely alerts to authorities and residents. According to Uche:

During the response phase, technology enhances situational awareness and resource management. Emergency response systems powered by AI and big data provide real-time insights into the scale and impact of crises, helping responders prioritize and allocate resources efficiently. Mobile communication platforms ensure rapid information dissemination to affected populations, while drones and robotics assist in search, rescue, and delivery of supplies in inaccessible areas (182).

In recovery, technology aids in damage assessment and reconstruction planning. Blockchain and digital platforms improve transparency in resource allocation, ensuring accountability in rebuilding efforts. Virtual platforms provide psychological support to victims, while data analytics identify areas needing long-term intervention. following Uche's position above, Bello argued that"

Globally, countries like Japan and the United States have embraced technologies such as earthquake early warning systems and automated emergency networks to manage crises effectively. In Nigeria, the adoption of mobile platforms and data-driven tools for flood response is emerging (93).

Conclusively, while challenges such as cybersecurity risks, infrastructure gaps, and digital illiteracy exist, the relevance of technology in emergency response remains undeniable. It transforms crisis management into a proactive, coordinated, and resilient process, ultimately reducing the human and economic toll of disasters.

The current state of emergency management in Nigeria

The current state of emergency management in Nigeria is characterized by significant challenges in preparedness, response, and recovery, compounded by a range of institutional, infrastructural, and resource-based limitations. Nigeria, a country frequently impacted by natural disasters such as floods, droughts, and epidemics, as well as man-made crises like terrorism and civil unrest, faces growing demands for a more robust emergency management system. Despite efforts to improve the sector, the country's response framework often falls short in addressing the complexities of modern-day emergencies. Bello avers that:

One of the primary issues in Nigeria's emergency management is inadequate infrastructure. Many areas, especially rural regions, lack the necessary facilities to manage disasters, such as emergency shelters, roads for access, and reliable communication networks. This leads to delays in response and a lack of resources to address the needs of affected populations (55).

Additionally, Bello stress that; inadequate transportation infrastructure makes it difficult to move personnel and supplies to disaster-stricken areas in a timely manner.

Another critical problem is poor coordination among the various agencies involved in emergency management. The National Emergency Management Agency (NEMA) and state emergency management agencies (SEMAs) have overlapping roles, leading to inefficiencies and confusion during crises [6]. Local governments, which play a crucial role

in disaster response, often lack the capacity and resources to effectively implement emergency plans. There is also limited collaboration between governmental agencies and non-governmental organizations (NGOs), which are often pivotal in delivering aid during emergencies.

Furthermore, Afolabi is of the view that:

There is insufficient funding and budget allocation for emergency management in Nigeria. While disaster preparedness and response are important, the Nigerian government often prioritizes other sectors, leaving emergency management underfunded (44).

This financial shortcoming limits the purchase of essential resources, such as medical supplies, rescue equipment, and training for personnel. The lack of technological integration is another significant hurdle. While some advances have been made, such as the use of mobile apps for flood alerts, the broader adoption of digital tools like real-time data analytics, geographic information systems (GIS), and automated response systems remains limited. These technologies could significantly improve Nigeria's disaster response, but issues like digital illiteracy and cybersecurity concerns remain [7]. In summary, while Nigeria has made strides in emergency management, it faces significant challenges that hinder its ability to respond effectively to crises. These include inadequate infrastructure, poor coordination among agencies, lack of funding, and limited technological integration. Addressing these gaps through policy reforms, increased investment, and capacity building is crucial to improving the country's emergency management framework and resilience to disasters.

Key agencies involved in emergency management in Nigeria (NEMA, SEMA, etc.)
In Nigeria, several key agencies are involved in emergency management, with the National Emergency Management Agency (NEMA) playing a central role. NEMA coordinates federal disaster response and is responsible for formulating national disaster management policies. It works alongside State Emergency Management Agencies (SEMA) at the state level, which are tasked with coordinating responses and preparedness activities within their respective states. Olufemi argues that:

Local governments also have a crucial role, as they are often the first responders during emergencies. However, their capacity to manage disasters is often limited. The Nigerian Red Cross Society, along with various non-governmental organizations (NGOs), provides supplementary assistance during disasters, particularly in providing humanitarian aid and relief services (36).

Other specialized agencies, such as the Nigerian Meteorological Agency (NIMET), provide weather forecasting and early warning systems for natural hazards like floods and droughts. The Federal Road Safety Corps (FRSC) and Nigerian Police Force (NPF) also play essential roles in rescue operations, traffic management, and maintaining law and order during crises. These agencies must work together to enhance the efficiency of emergency management in Nigeria.

Current practices and challenges in Nigerian emergency response

The current practices in Nigeria's emergency response reflect ongoing efforts to improve coordination and preparedness, but several challenges hinder effective disaster management. Key practices include the establishment of early warning systems, emergency relief operations, and coordination between federal, state, and local governments. The National Emergency Management Agency (NEMA) and State Emergency Management Agencies (SEMA) lead response activities, while organizations like the Nigerian Red Cross and other NGOs play vital roles in delivering humanitarian aid. However, Akinola is of the opinion that:

Numerous challenges persist. One significant issue is inadequate infrastructure, which hampers timely access to affected areas, especially in rural regions. Poor road networks, limited medical facilities, and lack of disaster management equipment are recurring problems (11).

Additionally, the fragmentation and lack of coordination between agencies like NEMA, SEMA, and local governments often lead to inefficiency during crisis response.

Thus, funding constraints also limit the effectiveness of emergency response efforts, as government allocation for disaster management is often insufficient. Moreover, Olufemi following Akinola position above argues that:

The lack of technological integration, such as real-time data analytics and GIS systems, delays decision-making and response. Finally, logistical challenges in mobilizing resources, compounded by security concerns in conflict areas, often complicate efforts to provide aid (67).

These issues highlight the need for better infrastructure, inter-agency coordination, funding, and technology adoption to improve Nigeria's emergency management framework.

Innovations in smart governance for emergency management in Nigeria

Innovations in smart governance for emergency management in Nigeria are slowly transforming the country's approach to crisis preparedness, response, and recovery. As Nigeria faces frequent disasters such as floods, terrorism, and epidemics, there is a growing need for technological advancements to enhance efficiency and coordination. Key innovations in smart governance are being applied through the integration of data-driven systems, real-time monitoring, and digital communication tools. According to Afolabi one significant innovation is the use of mobile technology for emergency alerts and communication. As he argue that:

The Nigerian government has begun deploying mobile applications and SMS systems to provide early warnings about impending disasters, such as floods or disease outbreaks. For instance, flood alerts are sent to residents in high-risk areas using geospatial data and weather forecasts, enabling them to take timely action (72).

Additionally, Afolabi maintains that, Geographic Information Systems (GIS) and remote sensing technologies have been incorporated into disaster management efforts. These technologies allow for real-time mapping of disaster zones, enabling more effective resource allocation and damage assessment. The use of drones for search and rescue operations is another innovation, particularly in areas that are difficult to reach by traditional means. The Nigerian government, through agencies like NEMA, is also exploring the potential of big data and predictive analytics to improve disaster response. By analyzing large volumes of data, authorities can predict disaster trends and deploy resources more efficiently [3]. Despite these innovations, challenges such as limited digital infrastructure, inadequate funding, and capacity gaps remain. Overcoming these barriers is essential to fully realizing the potential of smart governance for emergency management in Nigeria.

Examples and potential impacts on emergency preparedness, response, and recovery

Examples of smart governance innovations in emergency preparedness, response, and recovery in Nigeria demonstrate the significant potential for technology to enhance disaster management efficiency. One prominent example is the use of mobile phone-based early warning systems. The Nigerian government, in collaboration with NEMA and other agencies, has developed SMS-based alerts to notify citizens of impending disasters, such as floods, fire outbreaks, or disease epidemics. These alerts enable people to take preventive measures, evacuate, or prepare for potential impacts, significantly improving preparedness levels across the population.

Another example is the deployment of Geographic Information Systems (GIS) and remote sensing technologies. These systems provide real-time data on disaster zones, allowing for effective mapping, monitoring, and decision-making. Yusuf is of the opinion that:

During floods, GIS technology helps authorities identify high-risk areas, mobilize resources accordingly, and track floodwater movement. Drones have also been used in search and rescue operations, providing real-time aerial views of disaster areas that are difficult to access by road (24).

The potential impacts of these innovations on emergency preparedness are profound. Real-time data and predictive analytics can improve decision-making, ensuring quicker, more accurate responses. In terms of recovery, technology helps with damage assessments and resource allocation, ensuring that aid reaches those in need efficiently. Additionally, smart governance can foster better inter-agency coordination, as data-sharing platforms enable seamless communication between federal, state, and local authorities, NGOs, and other stakeholders, promoting a more coordinated and effective response during crises.

Challenges to implementing smart governance in Nigeria

Implementing smart governance in Nigeria faces several challenges that hinder the effective use of technology in emergency management. One of the primary obstacles is inadequate infrastructure. Many parts of Nigeria, particularly rural areas, lack the necessary physical and digital infrastructure to support smart governance initiatives. Poor road

networks, limited electricity supply, and unreliable internet connectivity hinder the deployment and usage of modern technologies essential for efficient disaster management. Another significant challenge is the lack of skilled personnel and technical expertise. Bello avers that:

The successful implementation of smart governance requires a workforce trained in data analysis, GIS, artificial intelligence, and other advanced technologies. Unfortunately, Nigeria faces a shortage of professionals with the necessary technical expertise, which limits the full potential of these technologies in managing emergencies (94).

In his opinion, funding constraints also pose a barrier to the adoption of smart governance practices. While technologies like drones, GIS, and mobile applications are essential for disaster preparedness and response, the high costs of acquiring and maintaining such systems often exceed the available budgets for emergency management. Consequently, many agencies struggle to implement these solutions effectively. In addition, Oluwole argue that:

There are challenges related to data security and privacy concerns. The collection and sharing of data during emergencies raise concerns about misuse or cyber threats. Without a robust legal and regulatory framework to protect sensitive data, the implementation of smart governance may face resistance from stakeholders (34).

Finally, cultural and organizational barriers, including a lack of collaboration among government agencies and between the public and private sectors, further complicate the effective implementation of smart governance. These challenges must be addressed to fully realize the potential of technology in emergency management.

8. Conclusion

The implementation of smart governance and emergency management systems in Nigeria represents a critical step toward enhancing the nation's resilience, efficiency, and responsiveness in addressing emergencies. By leveraging technological innovations such as data analytics, Internet of Things (I.T), artificial intelligence, and mobile platforms, smart governance has the potential to revolutionize emergency management. These systems can improve early warning mechanisms, real-time communication, resource allocation, and stakeholder coordination during crises. However, the journey toward fully functional smart governance systems in Nigeria is fraught with challenges. Issues such as inadequate infrastructure, limited funding, cybersecurity threats, bureaucratic inefficiencies, and low digital literacy remain significant obstacles. Additionally, the need for robust policy frameworks, inter-agency collaboration, and inclusive stakeholder engagement cannot be overstated.

Addressing these challenges requires a holistic approach that combines technological advancements with capacity building, public-private partnerships, and community involvement. Investments in digital infrastructure, training, and research will be essential to harnessing the full potential of smart governance systems. Conclusively, adopting innovative solutions and addressing the inherent challenges will not only enhance Nigeria's

emergency management capabilities but also contribute to building a more resilient, adaptive, and inclusive society. This shift is vital for safeguarding lives, property, and national development in an increasingly complex and interconnected world.

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Aspects of cybersecurity specialist training for electric vehicle driver education in communities supporting cross-border electromobility

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Abstract
Objectives: to investigate the prerequisites for the development of compatible training modules on digital skills and competencies for training electric vehicle drivers and cybersecurity specialists of intelligent electric vehicle infrastructure in order to create and test safe, seamless, convenient and reliable mobility by electric vehicles in populated areas of the border regions of Romania, Republic of Moldova and Ukraine. Previous work: The work is based on the authors' recent research results on "Interregional Innovation Investments (i3) as a tool to support TEN-T digital transport corridors in the Republic of Moldova". Approach: Analysis of European and international experience, cross-border cooperation in the field of road cybersecurity capacity building contributing to quality training of didactic materials, managers, drivers and teaching staff. Results: Adaptation of modules on digital skills and competences into the curricula and training programs for car driver candidates and cybersecurity specialists to effectively promote the integration of rural localities in border regions into the pan-European electromobility system. In the context of smart rural specialization approaches, digital innovation should contribute to the sustainable development of human settlements. Recommendations are made for policy makers, practitioners and stakeholders to improve cybersecurity resilience and enable safer smart mobility between regions of neighboring countries. Impact: civil society, academics, researchers, practitioners, national and regional administrations, European Commission, JRC. Value: Initiating collaborative cross-border projects to address current social challenges and needs to improve road safety and cyber resilience of electric vehicles within digital transport corridors. The article contributes to the European standardization process of electric vehicle charging infrastructure and related services and to provide early feedback to customers.

Keywords: cyber resilience of electric transport, pan-European electromobility system, cross-border cooperation.

1. The context of cross-border e-mobility
Electricity as an energy vector for vehicle movements offers the opportunity to replace oil with a wide range of primary energy sources. This should ensure security of energy supply

and the widespread use of renewable and carbon-free energy sources in the transportation sector of EU candidate countries to reduce CO2 emissions. The tank-to-wheel efficiency of electric vehicles is about 3 times higher than that of internal combustion engine vehicles, and electric vehicles do not emit pollutants such as CO2, NOx, NMHC and PM. Electric vehicles (EVs) provide quiet and smooth operation and hence create less noise and vibration. Policies related to battery-powered vehicles mainly focus on technological optimization and market development. Future challenges in this area include reliability and durability of batteries and supercapacitors, battery weight and volume reduction, safety, cost reduction, improved hybrid electric powertrains, charging infrastructure and plug-in solutions [1].

A new report from the European Automobile Manufacturers' Association (ACEA) [2] reveals an alarming gap between the current availability of public charging stations for electric vehicles in the EU and what will actually be required to meet CO2 reduction targets. According to the ACEA report, sales of electric vehicles in the EU grew three times faster than the installation of charging stations between 2017 and 2023. Looking ahead, the EU will need eight times as many charging stations per year by 2030, according to industry estimates. According to the European Commission, 3.5 million charging points should be installed by 2030. Reaching this target will require the installation of around 410,000 public charging points per year (or almost 8,000 per week), almost three times the latest annual installation rate.

Electric vehicles can play an important role in reorganizing the transport sector of Moldova's neighboring countries, Romania and Ukraine. Researchers and practitioners from the EU border regions and candidate countries are joining forces to address common problems and challenges related to cross-border, interregional and transnational mobility, including electrification of transport (electromobility), which is a priority in the Community Research Program. The results of the joint innovation activities are intended to explain to the population of small towns and rural settlements how the large-scale deployment of electric vehicles can contribute to the realization of the 2030 Agenda for Sustainable Development. Electric vehicles, with significantly higher energy efficiency than traditional fossil fuel vehicles, have lower emissions per unit of energy used.

This energy efficiency advantage is due to the fact that electric motors have minimal heat losses compared to internal combustion engines and that EVs do not produce exhaust emissions. However, the overall emissions of electric vehicles are affected by the source of electricity used for charging. When charging from renewable electricity sources, electric vehicles are considered extremely environmentally friendly and produce virtually no emissions. Even when charging from a grid that includes non-renewable sources, EVs in some segments still exhibit lower emissions than their fossil-fueled counterparts. These factors emphasize that electric vehicles can play a significant role in achieving the Sustainable Development Goals [3]. Table 1 reflects the sustainable development goals and targets related to the electrification of transportation.

Table 1: EV-related Sustainable Development Goals and targets [3]

Goal	*Targets*
	7.2 By 2030, increase substantially the share of renewable energy in the global energy mix 7.3 By 2030, double the global rate of improvement in energy efficiency
	11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.
	13.2 Integrate climate change measures into national policies, strategies and planning.
	17.14 Enhance policy coherence for sustainable development

European best practice studies show that the achievement of the goal of national governments to have one million electric vehicles on the roads in Germany and two million in France depends not least on the possible cross-border use of the vehicles. Therefore, the use of electric vehicles requires equivalent conditions concerning infrastructure both in the border regions, small towns and rural settlements of the EC and in the candidate countries of the Republic of Moldova and Ukraine. Unlike other new technologies, the introduction of electromobility in Europe, as studies show, triggers immediate harmonization requirements. The essential difference is that electric vehicles have a mobility objective that takes place not only in a national context but also in an international environment. The interoperable use of electric vehicles requires unrestricted charging processes abroad. For this reason, Electric Vehicle Supply Equipment (EVSE) [4], firstly, must meet the physical requirements of EVs, such as connectors, and secondly, the ICT infrastructure must be compatible. The main problem that arises in the context of legal harmonization of electric mobility scenarios is that there is not even a national legislation that can be used as a prototype. Indeed, Germany, for example, did not adopt an electromobility law until 2015 [5]. However, the only content regulated by this legislation are issues related to traffic regulations. Other urgent topics, such as at least a rudimentary legal framework on how requirements for EVSE are set, are missing.

The common ways of achieving European harmonization in EU candidate countries can demonstrate the European Union's approach to harmonization through the example of fast charging systems and other aspects related to the use of electric vehicles in terms of their need for harmonization. In this context, a reliable partner for innovation projects at the European level can be the European Commission's Joint Research Center (JRC), which has more than 320 ongoing R&D projects that draw on a wealth of experience in collecting and analyzing electric vehicle data. The projects can be found in EV-Radar, an interactive tool that collects and illustrates current R&D projects in the field of e-mobility. The Green eMotion project has also helped to strengthen the collaboration between IREC and JRC,

culminating in JRC's creation of a “Data Collection and Reporting Guide for European Electromobility Projects” [6]. The report provides a useful guide for European mobility projects on what and how to monitor and report. It also provides a detailed description of the critical and additional elements needed for monitoring, as well as some ideas for quality control and data collection. The paper is based on Green eMotion's internal report “Guidelines for Demo Region Reporting” [7].

2. High-value datasets for cross-border electromobility

New opportunities for sharing cross-border geospatial open data sets [8] enable:

- Connect development regions to the Inspire Transport Network Road [9] for regional reporting on road, rail, air and water transport networks of European and international importance and related infrastructures, including the links between these different networks.
- Local authorities and interested organizations to plan the deployment of charging stations for electric vehicles, based on the creation of open data showing the location of charging stations for electric vehicles in settlements within a radius of 30-40 km from its borders.

The European Commission adopted a regulation on the implementation of high value datasets on December 21, 2022 and published it on January 20, 2023. The legislation establishes a list of specific datasets that provide important benefits for society, the environment and the economy. This list is based on six thematic categories of data:

- Geospatial;
- Earth observation, and environmental;
- Meteorological;
- Statistical;
- Company and company ownership;
- Mobility.

In order to analyze the use of electric vehicles and the behavior of their drivers during cross-border projects, testing, innovative organizations and public administrations must consider how large amounts of data can be stored and processed. For this reason, European practice shows that it is advisable to develop a data repository to ensure that any cross-border and intra-regional electromobility data can be handled in a safe and secure manner.

The main component of this data repository consists of several relational databases for raw data provided by drivers and electric vehicle manufacturers [10], as well as for processed and aggregated data (for further processing and analysis). The databases are surrounded by interfaces, tools and services that will be developed to enable import and processing of raw data (including cleaning, harmonization and aggregation). Subsequent export of filtered and aggregated data and extensive cross-border analysis are based on a unified data model and commonly accepted data and file formats. Before starting the development of the E-Mobility repository, various questions have to be answered regarding data security and privacy, as well as the process of data exchange and transfer between the involved partners of cross-border projects.

The planning phase of data collection should focus on three main topics: (1) compliance of the E-Mobility repository with the security and privacy requirements of data owners, (2) agreement on a standardized data transfer process across the project covering rural pilot communities and small towns, including manual and automatic actions with appropriate transfer protocols, and (3) agreement by each data provider on a common data exchange format, including data schemas and file formats.

Electric vehicle sales are growing rapidly around the world, but the road to mass adoption in Europe is getting bumpy. While tensions between the EU, the US and China are heating up over the race to produce electric vehicles, a new challenge is emerging in the EU electric vehicle ecosystem - data interoperability.

Electric vehicles are powered by energy, but their hidden fuel is data! Today, this data is stored in silos, preventing relevant ecosystem players - charging operators, distribution system operators (DSOs), automakers - from optimizing their services and improving the experience for electric vehicle users. Lifting this data lock-in is essential to accelerate electric vehicle production and mass-market consumer adoption in Europe. The basis for cross-border cooperation is the "Model agreements on interregional and/or intermunicipal cross-border cooperation in the field of spatial planning" [11]. These agreements are designed to coordinate all types of spatial data, including sensitive information belonging to individual drivers, companies operating electric vehicle fleets, or manufacturers involved in fleet testing. These sensitive data are personal data such as age, gender, occupation or income of drivers and fleet managers, data related to the person or vehicle such as driving behavior, location, geographical coordinates or vehicle technical data such as energy consumption, range or wear and tear. In 2023, the EVision report [12] presented six basic principles for mass adoption of electric vehicles. In the mobility sector, the vehicle itself is only part of the story. It must be supported by adequate charging infrastructure, smart grid technology that enables two-way energy flow, and digital services that make electric vehicle ownership simple, flexible, and enjoyable. Digitalization is a critical element to integrate different ecosystems, such as the automotive sector and the electricity sector, through secure and open data access and transfer.

That's why the EVision 2024 report focuses on data and interoperability to accelerate electric vehicle production. The electric vehicle is just the tip of the iceberg of a highly interconnected space made up of many players, from original equipment manufacturers (OEMs) and automakers who develop hardware and software for vehicles, to network operators who depend on aggregate data from network users to provide network connectivity, to charging point operators who build charging stations to connect to the electric grid, and e-mobility service providers who connect EV drivers to the electric grid Data must become interoperable across the value chain through standardized protocols, charging roaming networks, network congestion heat maps, and common platforms to eliminate data silos. Data interoperability can solve many problems in the e-mobility ecosystem (Fig. 1) and improve the customer experience [12].

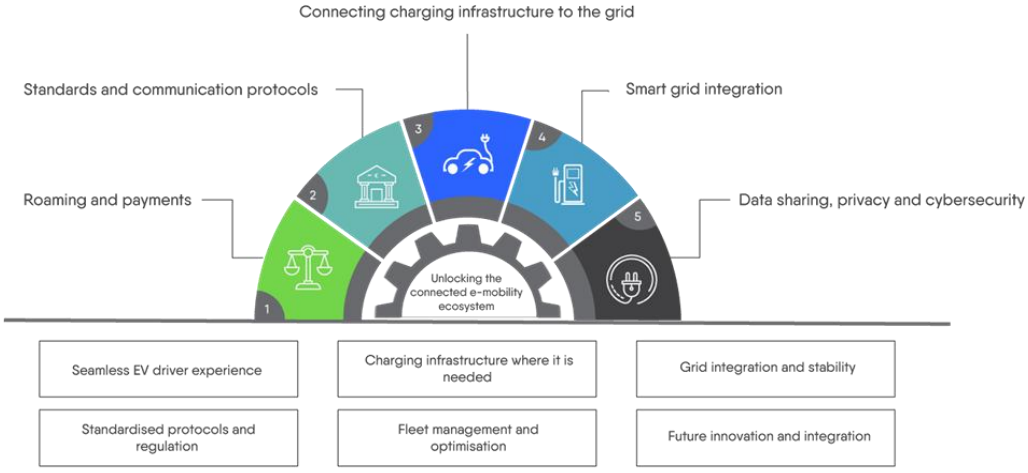

Fig. 1. Enabling the development of a mobility ecosystem [12]

In our study, we explore data interactions in three main activities in electromobility:

- Charging station optimization: strategically located charging stations that are accessible, powered by renewable energy (where possible), reliable, and scalable;
- Smart grid integration: seamless integration of electric vehicle charging with the grid for flexibility;
- Optimized charging process: user-friendly consistent and seamless access to charging infrastructure across different charging networks;
- Europe is uniquely positioned to standardize data interoperability across the continent, which is a competitive advantage for European businesses, from automotive companies to utilities. By leveraging this competitive advantage, regions and localities can push forward, decarbonize road transport, support urban resilience and protect the European automotive industry. Failure to capitalize on these advantages will leave Moldovan regions and local initiative groups in rural areas, widen the sustainability gap, and ultimately increase costs for both businesses and customers.

Solving the electric vehicle data problem, on the other hand, will give Europe a revitalized momentum compared to the rest of the world. If EU countries succeed, the future digital e-mobility ecosystem will be fully connected, integrated and interoperable. And through this complex smart grid, electric vehicles, electric vehicle manufacturers, smart charging stations, service provider charging systems, energy suppliers and smart grid systems will seamlessly interact and share information in real time. They will be able to provide freedom of choice for consumers, better services and cost savings, and reduce competition between suppliers by supporting innovation and scalability.

The UN Global Technical Regulations (GTR) on the Safety of Electric Vehicles (SEV) [13] addresses the safety aspects of the high-voltage electrical system, electrical components such as electrical connectors and sockets and, in particular, the RESS containing flammable electrolyte. In addition, the BEM team will examine technological issues in the design, development and manufacture of lithium batteries. Safety prescriptions

will cover safety elements of electric vehicles both during operation and after accidents. Key aspects include the following:

- During exploitation:
  - Occupant protection: protection against electric shock;
  - Recharging requirements, including electrical outlet and plug requirements;
  - Safety requirements related to RESS, including battery safety (battery management system, thermal shock, thermal cycling, mechanical shock, overcharge protection/insulation resistance, overcharging, vibration, fire resistance, short circuit, etc.).
- Post-accident:
  - Electrical insulation: protection against electric shock;
  - Battery integrity: battery management system, durability and survivability;
  - Best practices or guidelines for manufacturers and/or first responders after an accident;
  - Battery discharge procedures.

To the extent possible, the experts of the subgroup will develop the Global Technical Regulation UN using the following procedures:

- Identification of potential safety risks specific to EMs based on their actual operation;
- Development and evaluation of requirements by reviewing the analyses and assessments conducted to support the requirements;
- Developing and approving test procedures based on existing assessments and scientific studies;
- Avoiding the development of requirements containing design limitations and technically unsound prescriptions.

3. Security solutions for electric vehicles and charging infrastructure

Technological advances in electric vehicles (EVs) and supporting systems can create vulnerabilities in our critical infrastructure. JRC's research institutes and innovation centers are helping to protect the EV ecosystem with cybersecurity services that span embedded systems, EV charging infrastructure, wireless communications, and more. One of them, the "European Interoperability Center for Electric Vehicles and Smart Grids" [14] includes four state-of-the-art laboratories that combine knowledge and testing facilities in the areas of efficiency, hybrid exhaust emissions, EMC, smart grids, and battery testing.

The European Center establishes a transatlantic bridge with its partner facility at the U.S. Department of Energy's Aragon National Laboratory. The VeLA laboratories, two of which are located in Ispra, Italy (VeLA 8: Test Center for Electric and Hybrid Vehicles, VeLA 9: Test Center for Electromagnetic Mobility) allow the experimental evaluation of electric vehicles' functionality, energy efficiency, driving range, electromagnetic compatibility and, for hybrid vehicles, exhaust emissions. The Smart Grid Interoperability Labs deployed at JRC's Ispra and Petten sites support EU policy development by testing device and system interoperability in accordance with applicable standards and with reference to relevant architecture and use cases.

On 31 May 2023, during the fourth ministerial meeting [15] of the EU-US Trade and Technology Council (TTC) in Lulea, Sweden, the European Union and the United States reaffirmed their commitment to developing a standardized vision for charging electric heavy-duty vehicles (HDVs). According to a joint statement, both parties recognize the importance of the Megawatt Charging System (MCS), adopted by international standardization organizations IEC, SAE and ISO, for charging electric HDVs. The new standard will enable fast charging of electric HDVs along highways and is necessary to reduce charging times to match drivers' legal rest breaks and enable the adoption of zero-emission long-haul freight transport. The MCS also has potential for application in various sectors, including aviation, inland and maritime transport. As part of their cooperation, the EU and the US will collaborate on the development of a transatlantic test procedure for high-power charging, ensuring interoperability, charging system performance, and reduced manufacturing and deployment costs.

In addition, the European Commission's Joint Research Centre (JRC) and the US Department of Energy's Aragon National Laboratory (ANL) published a joint document on the same day, including technical recommendations. The document, titled "Transatlantic Technical Recommendations for Government-Funded Deployment of Electric Vehicle Charging Infrastructure", aims to accelerate the deployment of electric vehicle charging infrastructure, promote harmonized standards, remove trade barriers, and facilitate the integration of renewable energy, grid stability, and greener road transport.

Technological advances in EVs and their supporting systems can create vulnerabilities in our critical infrastructure. Southwest Research Institute [16] helps protect the EV ecosystem with cybersecurity services that cover embedded systems, EV charging infrastructure, wireless communications, and more. EV nodes such as vehicles, smart chargers, and the power grid are targets for cyberattacks. A successful attack can compromise personal information, disrupt charging processes, and threaten grid stability. One security solution for EVs and charging infrastructure is shown in Fig. 2.

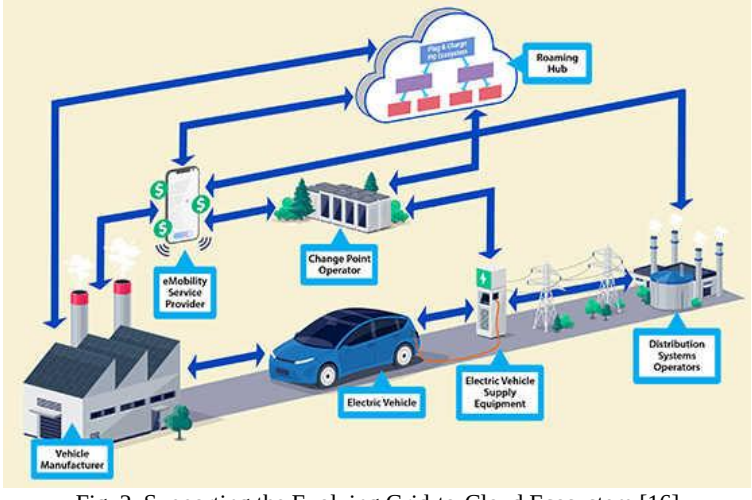

Fig. 2. Supporting the Evolving Grid-to-Cloud Ecosystem [16]

The capabilities of this solution consist of:

- EV and EV charging cybersecurity, including:
  - Vulnerability Analysis: Conduct thorough assessments of the entire EV ecosystem to identify vulnerabilities and secure customer systems;
  - Penetration Testing: Conduct comprehensive security assessments of vehicles, charging infrastructure, and associated systems to identify vulnerabilities and demonstrate real-world attacks;
  - Vehicle to Vehicle (V2X): Implement V2X communications for secure data exchange, coordination, and compliance.
- Cybersecurity Architecture, including:
  - Architecture Review: Conduct architectural assessments;
  - Zero Trust Architectures (ZTA): Design ZTAs for production environments.
- Research and Modeling, including:
  - EV and EV charging cybersecurity research: Conduct targeted research to address customer and domain concerns between the EV, EV charger, and their various interfaces using best practices;
  - Vehicle and EVSE modeling: development of customized simulation models that reflect charging infrastructure and operating scenarios.
- Integration and Innovation, including:
  - Autonomous Vehicles: Ensuring the security of autonomous vehicle technologies and their integration with charging infrastructure;
  - Personal, Commercial, Military, and Off-Road Vehicles: Adapting cybersecurity solutions to different vehicle types;
  - Embedded Systems: Optimizing embedded systems used for vehicle components, charging infrastructure, and network equipment;
  - Smart Grid Technology: Integrating smart technologies into operational environments.

4. Strategies for teaching the operation of e-vehicles

The main pedagogical and didactic aspects of digital and virtual education and training, focused on the needs of teaching staff in e-vehicles, include theoretical and practical aspects. They focus on the use of self-produced digital teaching materials and trainings, as well as how to develop and create these materials.

Electric cars, e-scooters, e-motorcycles and other electric vehicles are now a reality and not something exotic or of only research interest, as they seemed a few years ago [17]. Electric vehicles and their associated operating procedures are widespread throughout Europe and are steadily increasing their market share. However, this penetration, as well as the increase in supporting infrastructure, is not uniform within the EU. In the countries of Southern and Eastern Europe, and especially in the regions of the new EU candidate countries, the market penetration of electric vehicles is not yet considered significant.

As a result, the existing knowledge in the field of vehicle electrification at the national, regional and local level is practically very small. Infrastructure, such as charging stations, in this area is quite limited. This leads to a general ignorance of vehicle electrification not only among the population but also among people working in the vehicle industry. The

educational results of educational programs aimed at training engineers, mechanics and vehicle-related personnel with the above-mentioned difficulties, synergies such as those obtained between universities and companies in the border regions of the candidate countries, should not only cover the gaps existing at the national level, but also provide a full range of education regarding electric vehicles. Private companies and research institutes specializing in vehicle electrification, such as the development of relevant technologies or the production of specialized vehicles, should provide consumers with the necessary practical knowledge on the production and operation of electric vehicles, measurements, hybridization and troubleshooting, as well as vehicle maintenance.

4.1. Theoretical aspects

Digital and virtual education and training is simply the introduction of new technology into the education of students. Educational technology in itself is not important, only in the context of a certain content (learning outcomes) and a pedagogical and didactic method can it add a new dimension to education. The main pedagogical and didactic aspects of digital and virtual education and training, oriented towards the needs of e-vehicle teaching staff, include:

1. Responsibility for one's own learning, as a concept, is considered in connection with the shift from talking about learning to direct teaching. The shift is associated with distancing from the concept of learning, where knowledge, values or motives are transmitted from the teacher to the student, while the concept of learning indicates that the student actively constructs knowledge, values and motives himself. From this point of view it follows that no one can teach anyone anything. In other words, the students themselves must take "responsibility" for their learning.

2. Work Based Learning assumes the integration of theoretical education into practical learning. Action learning refers to the educational theory developed by the American philosopher John Dewey. It is a hands-on approach to learning, meaning that learners must interact with their environment in order to adapt and learn.

3. Project-Based Learning is a learner-centered pedagogy that involves a dynamic approach to learning, in which learners are believed to acquire deeper knowledge through active exploration of real-world tasks and problems. This pedagogical approach also finds its roots and first concept in John Dewey.

4. Hybrid Learning. The terms "hybrid learning", "blended learning", "technology-mediated learning", "web-enhanced learning" are often used interchangeably, but what all of these terms have in common is an approach to education that combines online learning materials and opportunities for online interaction with traditional on-site classroom teaching methods. It requires the physical presence of both teacher and student, with some element of student control over time, location, route, or pace. While students still attend "physical" schools with a teacher present, face-to-face classroom instruction is combined with computer-mediated activities in terms of content and delivery.

5. The Concept of Flipped Classroom. It is a type of blended learning. A flipped classroom is a learning model in which the teacher provides material for independent study at home

and the classroom provides practical reinforcement of the material. Flipped learning can be described as a technology-supported approach to teaching where active student learning is at the center. The terms flipped learning and flipped classroom are used interchangeably in practice. Both concepts involve teaching and learning using short videos to convey academic content and instructions that students would normally receive in a classroom. After reviewing the videos and answering additional questions before teaching, the classroom can be used for student-centered learning activities.

6. Automotive Cyber Security Course. Within the three-day certification training course "Automotive Cyber Security Training", participants undergo a detailed and practical training course on the cybersecurity aspects that need to be taken into account in the context of automotive products. Trainers will teach theory and practice in the following areas:

- Fundamentals of cybersecurity and specific requirements for the automotive industry.
- Type approval requirements according to UN Regulation No. 155 [18], the basics of ISO/SAE 21434 [19] and their application in automotive projects.
- A practical introductory course to improve know-how, understanding and comprehension of the requirements of standards and regulations.

As a participant, you can take a 75-minute exam to obtain the TUV NORD certificate "Automotive Cybersecurity Engineer (ISO/SAE 21434)" [20]. The learning outcomes are holistic (end goals of the competencies) or modular (knowledge, skills and competencies). The recognition of the achieved learning outcomes is one of the provisions of the Bologna Process, and the modularization of VET is a central element of the European educational process (Bruges-Copenhagen process). The acquired competencies/qualifications and their (international) comparability should contribute to increased transparency. This involves a fundamental paradigm shift in the educational process. This means that the transfer of knowledge, which was previously controlled by the teacher or mentor, will be transformed into the acquisition of comprehensive competencies by the learners. The modularization of the educational content achieves the following goals:

- Vertical and horizontal permeability of the educational system;
- Comparability of the acquired skills;
- Development of professional skills;
- Crediting of formal, informal and non-formal competencies;
- Rapid adaptation of training programs to changes in the affected areas of activity;
- Support for the development of a personal profile through options.

7. Learning Management Systems (LMS). Learning management systems support educational processes in e-learning and help manage learning materials and user data. They enable the organization of learning processes and communication between participants. With the help of LMS, courses can be created, learning content can be uploaded and communication tools can be activated. Learning management systems are web-based and are characterized by the following functions:

- User administration;
- Course management;

- Distribution of rights;
- Provision of differentiated communication methods;
- Network presentation of learning content, learning objects and additional media.

The diagram below (Fig. 3) illustrates the architecture of an LMS. This structure, modeled on a regular school, is therefore also used in a digital learning environment.

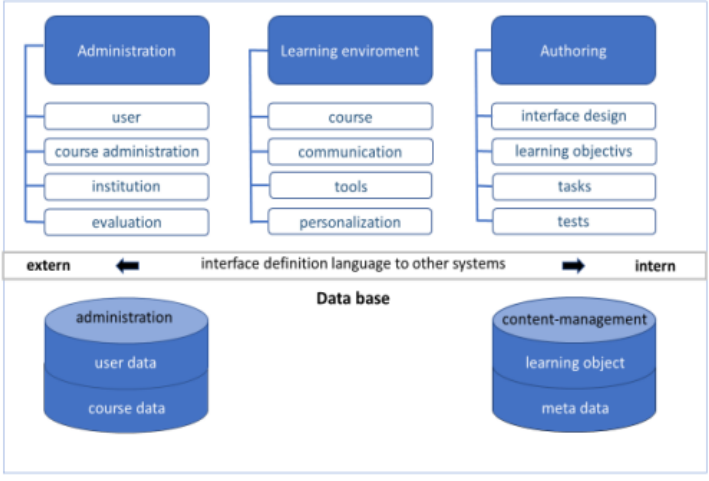

Fig. 3. Architecture of the Learning Management System [17]

4.2. Practical aspects

The growth of e-mobility and the associated technological changes in the automotive industry pose new challenges for vocational training. In the learning and training process, new knowledge and general skills must be imparted in a timely manner. Digital/virtual learning and training materials can support teachers and training personnel in the implementation process. This part of the guide offers practical tips for creating and using self-recorded learning and explanatory videos.

Learning and explanatory videos are particularly suitable as digital components to support the transfer of a theoretical program and/or to illustrate working methods and workflows:

- Basis for creating digital learning and training materials. It has been proven that creating a script and storyboard is useful at the beginning of the production of your own videos. The basic structure of the "classic storyboard" should be used as a guide. When developing a concept, three aspects must be taken into account: WHAT ➢ HOW ➢ WHY;
- Selection, work steps and tips for creating educational and explanatory videos. The didactic format (videos created by the teaching staff) in combination with the methodological goals (digital processing and transmission of relevant educational and practical content in the field of e-mobility) influence the choice of technology;
- Access rights, invitation, distribution, presentation and storage of digital educational and methodological materials. Digital educational and training materials must be accessible to students and teaching staff and reliably protected from unauthorized access. All partners involved in the learning process must have access to the materials at all times. This means that the data, as well as the software and hardware required to open

and use the materials, must be disposed of. It is not very useful to have access to a data file, but there is no legalized proprietary software for legal use.

One example of the best European practice in the development and use of digital teaching and methodological materials can be found in the results of the EU Danube Region Interregional Program project "Electric, Electronic and Green Urban Transport Systems" (eGUTS) [21], which exploited the potential of e-mobility in eight cities on the Danube and beyond. To this end, the existing network of 22 partners developed innovative eGUTS standards for cities and rural communities supporting e-mobility based on joint feasibility studies, developed and implemented local action plans for their deployment, developed and tested the eGUTS APP smart tool, implemented various pilot actions in the field of road preferences and parking policies, charging stations, rental locations, etc. The Consortium actively strengthens cooperation, exchange of experiences and transfer of know-how between the relevant actors both at transnational (through the Expert Group) and at regional and national level (through meetings of the Regional Strategic Platforms) with a focus on the needs of users (local residents and tourists). As a result, the application of the Danube eMOB strategy was improved and coordinated not only in the participating regions, but also, with wider use of the results, in the entire Danube Region and further across Europe. Thanks to the project, cities and rural communities in the regions of the European Danube Macro-Region have increasingly become supportive of electromobility and are actively introducing various measures to increase its share. To support their efforts, especially with regard to planning, the necessary guidelines, training materials and templates were developed. For example, the "Guide to the Local Action Plan" describes the project's approach and provides detailed step-by-step instructions on the process of developing a local action plan, together with a local action plan template and training materials. The training materials consist of six modules, each focusing on a specific topic.

- M1: Local Action Plan (LAP development process);
- M2: Public charging infrastructure;
- M3: Electric buses in public transport;
- M4: Electric vehicles in municipal fleets;
- M5: eRental: eStations and eStock;
- M6: Other events.

5. European harmonization in the context of electric mobility infrastructure and from a legal perspective

Since different legal systems are an obstacle to a common European market, legal harmonization may be the only acceptable means to prevent the disruptions that are characteristic of the union. Legal harmonization may be initiated to create a European market, in the sense that there are no internal borders, which at the same time ensure the free movement of goods, persons, services and capital. Art. 26 TFEU [21] states that the Union shall take measures with a view to establishing or ensuring the functioning of an internal market. According to Art. 114 TFEU, the EU may use (among other things) directives and regulations as legal instruments to achieve this objective. Unlike a regulation, which enters into force in all European countries at the same time, a directive must be implemented into national law by the Member States.

Harmonization measures may be applied where barriers to trade exist. Therefore, a directive or regulation should not be used in an abusive manner to achieve harmonization in an area where the EU has no legal competence. Art. 114 TFEU should only be used to avoid creating barriers to trade due to the uneven development of national provisions. Indeed, in the field of electromobility, the European Commission has identified the need for action and has therefore developed a proposal for a directive on the deployment of alternative fuel infrastructure. In Art. 4 COM (2013) 18 final [22] the directive sets out the elementary provisions concerning the electricity supply to vehicles. The most important issue is the harmonization of plug and socket systems used for electromobility, which is to be regulated in Annex III COM. The reason for the harmonization of plug systems is to enable cross-border use throughout the EU. Since the EU also considers environmental protection to be a European objective, European harmonization could also be possible on the basis of the competences laid down in Art. 191 in conjunction with Art. 192 TFEU. Legal harmonization will therefore also help to protect the environment, which cannot be limited by national borders.

5.1. Harmonization issues from an infrastructure perspective

5.1.1. Identification system

When thinking about harmonization topics, the identification system should be considered. In this matter, both the technical issues of how to subscribe to a public EVSE and the standard for the customer identifier structure, if applicable, so that each user, vehicle or contract can be identified across Europe, need to be taken into account. In the meantime, the standardization of the identification number scheme is moving forward. ISO 15118-2 now contains a provision that allows for identification across Europe. The other issues mentioned, how a user can subscribe to a public EVSE, are still under discussion. Indeed, ISO 15118-1 also contains provisions on this issue, but still offers different possibilities. Options currently under discussion include plug & charge (authentication via EV-EVSE cable connection), credit card payment and the use of other communication infrastructures such as mobile phones, local Wi-Fi and direct registration on a public EVSE.

5.1.2. Billing system

Another indicative part of the electromobility system for cross-border charging processes is the billing system, which should probably be harmonized at least in a rudimentary form. In this regard, it should be noted that there are currently two different concepts of how the metering data that is the basis for billing can be collected. In the case of mobile metering [23], the electricity meter is either assembled inside the electric vehicle itself or integrated into the power cord. In addition, the concept of stationary metering places the electricity meter inside the EVSE. Both concepts have advantages, but also suffer from some disadvantages. Indeed, this harmonization problem seems to have been solved since the entry into force of Art. 4 No. 6 COM 2013 (18) definitively establishes that “all publicly accessible charging points for electric vehicles must be equipped with intelligent metering systems as defined in Article 2(28) of Directive 2012/27/EU” [24], but this provision does not necessarily lead to the conclusion that only a fixed system will be legitimized.

For international charging processes, an additional process concerning the handling of meter data needs to be harmonized, since it is expected that the invoicing of both the

contractual partner towards the customer and the invoicing between the companies involved will be based on these values. Finally, it should be noted that there must be a harmonized way of exchanging the required data arising from the charging process. Otherwise, there is a risk that the data exchanges processes will differ between the different Member States or even between the different EVSE operators and will therefore have to be implemented in many different ways by one company.

5.2. Harmonization issues from a legal perspective

In addition to the infrastructural perspective, possible harmonization issues can also be considered from a legal perspective. Indeed, not all areas of law that influence the establishment of EVSEs have an impact on international charging processes. For example, the law on public streets and roads that affects the establishment of EVSEs is irrelevant in the international context, since it only concerns the question of whether an EVSE can be built in a certain location. Areas of law that affect international charging processes are, for example, energy and metering law.

5.2.1. Energy law

First of all, energy law must be taken into account in the context of electromobility. National legal frameworks concerning energy law, such as in Germany the EnWG [25], are already affected by European legislation today. For example, the Electricity Directive 2009/72/EC [26] or the Energy Efficiency Directive 2012/27/EC [27] influence national energy law. The main question concerning electromobility in the context of energy law is whether EVs should be considered as part of the smart grid and thus part of the energy market, or whether they are simply normal consuming appliances and the energy market ends with the EVSE. Since EVs will also be used to work for the benefit of the grid [28], in the future, a perspective that includes EVs in the energy market will probably be a more effective way of designing the future smart energy system.

5.2.2. Metering law

The metering law is also partly determined by European legislation. The European Metering Instrument Directive (MID) 2014/32/EU [29] regulates, among other things, the technical requirements that active electricity meters must meet. Since public EVSEs must be equipped with intelligent metering systems [30] and energy metering by selling electricity to users of electric vehicles is necessary due to the potential use of electric vehicles for the benefit of the grid and the required efficiency targets [31], a regulation concerning electricity meters must be taken into account. The possibility of developing specific requirements for electric vehicles should be considered, since the current specifications in the MID cannot be converted without problems in all respects.

European harmonization is an important and valuable tool for avoiding heterogeneous developments in Member States. Particularly in the field of electromobility, divergent rules are counterproductive. Harmonization of systems across Europe is therefore mandatory. The harmonization of the charging socket system is indeed a very valuable step towards the cross-border use of electric vehicles. However, as can be seen, the proposal of the directive COM(2013)18 final does not cover all the relevant issues in the context of

electromobility, which means that there are still some topics that would also be worth harmonizing.

The future market for electromobility offers, thanks to the possibility of early harmonization, a real chance to avoid mistakes that, for example, were made with other technologies in the past. Since electromobility systems are not yet well established in the Member States, there is an opportunity to build a compatible system from the bottom up, without major changes to national regulations. In this way, the financial risks can also be reduced. However, the starting point must be established now.

6. Conclusions and recommendations

This article is aimed at national and local administration leaders, business and driving school mentors, electric vehicle and e-mobility infrastructure cybersecurity engineers and technicians, teachers, instructors who are involved in the initiation, development and management of cross-border e-mobility. The authors' recommendations for the development and implementation of digital learning and training concepts, as well as the creation and production of digital teaching materials in a cross-border context, take into account that it is impossible to have a single cybersecurity governance as such, but it is important to talk about governance, i.e. a structure that will allow various public and private actors to cooperate across borders. The proposed solutions for the training of highly qualified specialists and personnel for the operation of e-mobility infrastructure are based on the adaptation of the methodology of the European Cybersecurity Competence Centre (ECCC), which includes:

- Border regions, European cross-border regions can play a key role in promoting and disseminating cybersecurity products and services in the neighboring countries of Romania, the Republic of Moldova and Ukraine, reducing the dependence of the new EU candidate countries on third-country and non-European solutions;
- Since the European cybersecurity landscape of the near future will be influenced by initiatives that have a direct impact on regional ecosystems, including the “European Network of Cybersecurity Competence Centers”, European regional digital innovation centres (in cooperation with universities) and updated smart specialization strategies in each border region should take into account the growing needs and risks of the deployment of charging infrastructure and cross-border e-mobility in general;
- Cross-border Security Operations Center (SOC) platforms should enable and encourage the exchange and consolidation of large volumes of cybersecurity threat data from multiple sources in a secure environment, and provide their members with high-quality, actionable information and training programs for electric vehicle and e-mobility infrastructure cybersecurity engineers and technicians through expert analysis and the use of modern information tools and infrastructure. This should contribute to improving detection capabilities and ultimately preventing and responding to cyber threats and incidents.

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RRReMaker project's key exploitable results methodology: a framework for AI-driven circular production

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Abstract

The shift towards a circular economy is essential as environmental and resource challenges continue to grow. This paper presents an AI-based platform that addresses these challenges by connecting digital manufacturers, traditional crafts, and green companies enabling the design and production of sustainable, handcrafted, and reconditioned products using recyclable materials. The research is based on the RRREMAKER project and the focus will be on the project's exploitable results that have the most potential for commercialisation, dissemination or future research. The project builds on prior research and knowledge in circular economy by integrating circular design and resource techniques for innovative AI solutions and appling AI and circular practices for efficient product design. The methodology for identifying the Key Exploitable Results (KERs) of the project involved mapping the project objectives to potential exploitable outcomes, engaging stakeholders, market analysis, developing evaluation criteria and exploitation plans. The results of the research consist of the most significant outcomes that such a platform can provide, the status, the maturity level and the main target market and potential stakeholders for each outcome, and the expected economic, environmental and social benefits. This study provides useful insights for scholars and practitioners in sustainable design and circular economy, demonstrating how AI-powered platforms may integrate digital and traditional craftsmanship to encourage eco-design and scalable waste reduction strategies. The paper introduces an innovative AI-powered platform that links digital and traditional design techniques to enable circular economy-friendly production. Its unique contribution is the use of modern technology to optimise material utilisation and minimise waste, resulting in a scalable solution for environmentally responsible manufacturing.

Keywords: circular economy, AI-driven platform, waste reduction, resource efficiency, stakeholder engagement

1. Introduction

In an era defined by technological innovation and environmental consciousness, the convergence of artificial intelligence (AI), circular economy principles, and traditional craftsmanship offers unprecedented opportunities for transforming how we design, produce, and consume goods. In this paper, we will present the RRREMAKER project, which aims to integrate these domains into a unified platform. The solution aims to transform product design and manufacturing by developing an AI-based platform, aiming to enable the creation of handcrafted, rapid-prototyped, and reconditioned products using recyclable waste and repurposed materials, establishing new standards for sustainability and innovation in design and production.

The platform will function as an ecosystem where digital manufacturers, artisans, designers, creative companies, and green businesses collaborate. By using AI, machine learning, and cutting-edge algorithms, RRREMAKER introduces a disruptive approach to product development, where technology plays a central role in the creative process.

- This intelligent computational platform will not only facilitate the sharing of information across diverse sectors but will actively contribute to the design and production process. Its capabilities include:
- Generative Design Algorithms: Utilizing techniques like genetic algorithms and superquadric-based modeling to predict and propose optimal structures, materials, and aesthetics for products.
- Big Data and Machine Learning Integration: Harnessing data from recyclables, market trends, and traditional design parameters to inform innovative and sustainable solutions.
- Ecodesign and Resource Optimization: Enabling efficient use of recyclable materials and minimizing waste throughout the production cycle.

2. Related work

Despite advances in information and communication technology, many sectors, especially traditional crafts and manufacturing, struggle to integrate digital tools effectively. Existing research highlights the competitive advantages of digital transformation in distribution and marketing but reveals a gap in its application to production processes. RRREMAKER addresses this gap by demonstrating how AI and machine learning can revolutionize not only the production chain but also the broader economic landscape.

The authors of this paper [1] address the role of machine learning in modern manufacturing, namely additive manufacturing. It is enabling the production of high-quality products with reduced labour, time, and resource requirements. Despite its advantages, the widespread adoption of machine learning faces significant barriers, including the high implementation costs and the need for specialized expertise, which can be particularly challenging for small and medium-sized enterprises. Recent research demonstrates that machine learning excels in optimizing process parameters, enhancing equipment efficiency, and advancing material-property relationships. However, further efforts to bridge the gap between theoretical advancements and real-world applications are needed, as many of these solutions remain untested in practical industrial setting. Overcoming these limitations and

showcasing tangible examples of machine learning's impact in manufacturing will be essential for its broader acceptance and utility.

The authors of this paper [2] argue that digital transformation plays a crucial role in advancing sustainable manufacturing by integrating technologies like IoT, AI, Big Data, and digital twins to optimize processes, reduce waste, and improve energy efficiency, as these innovations are aligned with Industry 4.0 goals. Technologies like digital twins further contribute by enabling real-time system monitoring and virtual testing, despite the challenges posed by high implementation costs.

This study [3] investigates the rapid development and impact of artificial intelligence in manufacturing between 2019 and 2024, highlighting its role in enhancing efficiency, automation, and business opportunities. The authors' bibliometric analysis revealed a consistent rise in publications on topics like predictive maintenance, additive manufacturing, and machine learning. They have identified a peak in productivity in 2023, though a decline in average citations per article suggests a dilution of individual research impact. Influential authors and journals have been pivotal in advancing themes such as "smartization," anomaly detection, and process optimization. Key challenges include technological complexity, limited infrastructure, and ethical concerns, while opportunities exist in predictive maintenance, process customization, and data-driven decision-making. Addressing issues of scalability, integration, and interdisciplinary collaboration will be critical for realizing AI's full potential in manufacturing. This research offers a comprehensive overview and actionable insights to guide further developments in the field.

Furthermore, by adhering to the "3R" principles: Reduce, Reuse, Recycle, the platform aligns with global sustainability goals, promoting environmental stewardship while delivering tangible economic benefits to European society.

3. RRREMAKER key exploitable results

A series of Key Exploitable Results (KERs) have been identified within the RRReMaker project that constitute the foundation of its innovative strategy for advancing sustainable production and circular economy principles. These results provide practical frameworks and solutions for promoting environmental sustainability and are aligned with the project's objectives.

KER #1: Comprehensive knowledge database

The Knowledge Database serves as a resource for sustainable design and production, currently in its prototype/testing phase with mid-stage maturity. It integrates extensive data on material properties, environmentally friendly manufacturing methods, and traditional artisanal practices. This resource provides key stakeholders—especially designers, educators, and sustainability consultants—with actionable insights to implement greener, more efficient production methodologies. The potential market segments that can benefit include diverse groups such as designers, manufacturing companies, artisans, sustainability consultants, educational institutions, environmental NGOs, startups, and corporate sustainability departments.

KER #2: AI-powered design and optimization modules
The AI-Powered Design and Optimization Modules use advanced algorithms to support sustainable practices by enabling the reuse and repair of products. Currently at a mid-stage prototype/testing phase, these modules have the role to automate tasks like generative design and material selection, helping manufacturers and researchers create sustainable products. They also facilitate the retrieval and regeneration of components for damaged objects, promoting a circular economy.

Targeted users include manufacturing companies seeking to optimize assembly and repair processes, designers in maker spaces who need efficient prototyping tools, and sustainability consultants supporting green initiatives. Educational institutions and artisans also benefit from these tools, which enable innovation and practical learning.
The modules deliver economic benefits by reducing costs, enhancing efficiency, and fostering innovation. Environmentally, they cut waste, conserve resources, and lower energy use. Socially, they improve access to affordable repairs, support local businesses, and aid cultural preservation efforts.

KER #3: The RRReMaker platform
The RRReMaker Platform combines human-centered design with advanced machine learning to create a versatile tool for sustainable innovation. It acts by integrating data from diverse sources and making use of high-performance computing. The platform optimizes production workflows, accelerates product development, and enhances supply chain sustainability. The current stage is the prototype/testing phase and it targets a broad audience, including manufacturers, startups, and artisans in emerging markets.

Key features include tools for eco-design, virtual prototyping, and resource optimization, enabling users to improve product sustainability and efficiency. Startups and artisans benefit from access to advanced technologies and collaboration opportunities, fostering innovation and sustainability across industries. The platform also supports supply chain management with real-time insights and predictive analytics, helping streamline operations, reduce waste, and lower costs.

KER #4: Collaborative knowledge-sharing network
The Collaborative Knowledge-Sharing Network serves as a dynamic virtual platform facilitating interaction and cooperation among key stakeholders, including artisans, designers, manufacturers, and policymakers. It focuses on enabling the exchange of ideas, dissemination of best practices, and access to emerging market opportunities. It also has a distinct focus on empowering marginalized groups, particularly women artisans and it ensures equitable participation by providing essential digital tools and training. This initiative establishes a structured ecosystem that promotes inclusive growth and advances sustainability across diverse sectors.

Collectively, these Key Exploitable Results represent the project's commitment to the use of technological innovation and circular economy principles to reshape production and design practices. They provide a scalable and adaptable framework for addressing global

sustainability challenges, delivering substantial environmental, economic, and social benefits.

4. Conclusions

The RRReMaker project represents an innovative approach to tackling the challenges of sustainable production by combining advanced artificial intelligence (AI) with circular economy principles. The project has developed Key Exploitable Results (KERs) that not only provide practical tools for advancing sustainability across industries but also offer a replicable model for fostering eco-friendly innovation globally.

The project offers a fresh and practical approach to sustainability by transforming research into actionable, real-world solutions. With a methodical process that includes setting clear objectives, engaging key stakeholders, conducting in-depth market research, and evaluating the impact, the project provides a clear path for industries looking to adopt sustainable practices. By considering the broader economic, environmental, and social impacts, it offers a comprehensive framework for businesses to transition towards production systems that are both eco-friendly and inclusive. The project's adherence to circular economy principles ensures its solutions are not only innovative but also flexible enough to be applied across a variety of sectors.

Looking to the future, the scalability of the RRReMaker framework presents a promising opportunity for broader adoption. In the coming phases, efforts will focus on refining and testing the prototypes through larger-scale pilots, with attention to adapting the solutions to suit different industries and cultures.

Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No. 101008060.

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Europe`s digital twins

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Abstract
This paper explores digital twin technology and its potential in achieving the goals outlined in the "2030 Digital Compass: the European model for the digital decade." By analyzing best practices across Europe in implementing digital twin technology, the article aims to identify the key benefits of using this technology as well as the lessons learned from its pioneers and the main challenges they encountered. This article offers an insight into digital twin technology and provides a perspective on how we can anticipate and address some of the most important challenges in the development of smart cities, such as urban planning, traffic management, and air pollution.

Keywords: smart cities, digital twin, innovation, supercomputing, digital decade.

1. Introduction
The role of digitalization and how it is perceived were radically changed as a result of the Covid-19 pandemic, with digital technologies becoming essential for all areas of activity in the society we live in. Thus, the European Commission, through the ”2030 Digital Compass: the European model for the digital decade”outlines new directions for digital action: [1]

1. A population with digital skills and highly qualified professionals in the digital field(the Action Plan on the European Pillar of Social Rights aims for 80% of adults to have at least basic digital skills by 2030);
2. Sustainable, secure, and high-performance digital infrastructures(the European Commission's aspiration is that by 2030, all European households will have gigabit networks, and all populated areas will be covered by 5G);
3. Digital transformation of businesses(among the measures targeted by the European Commission, it is envisioned that by 2030: — 75% of European companies will use cloud computing, Big Data, and artificial intelligence services; over 90% of European SMEs will achieve at least a basic level of digital intensity);
4. Digitalization of public services(the European Commission's objective for this action area is to create ”Government as a Platform”, a new way of developing digital public services. This approach will offer global and easy access to public services, with continuous interaction of advanced capabilities such as data processing, artificial intelligence, and virtual reality).

On the other hand, the Strategic Foresight Report 2022, “Twinning the green and digital transition in the new geopolitical context”, highlights the fact that digital twins could facilitate innovation and the design of more sustainable processes, products, or buildings. [2].

European Commission in the paper ”Digital Twins-Integrated Planning Factsheet (2021)”, define digital twin as a digital representation of a physical process, person, place, system or device [3]. This allows for enhanced monitoring, analysis, and optimization of various

aspects of physical entities, whether they are machines, infrastructures, or even human health systems.

Urban digital twins can be used, both for planning and operational management in several urban domains, such as:

- Built environment
- Infrastructures
- Transport and accessibility
- Land use and spatial planning
- Environmental quality and pollution
- Climate change, prediction of extreme weather patterns
- Climate change adaptation, management of climate risks
- Energy efficiency and renewable energy sources
- Maintenance/asset management [3].

2. Research methodology

The research methodology will include document analysis as a research method aimed at identifying best practices in the implementation of digital twin tehnology in European member states. Among the documents I will study and consider are: national or European, official documents regarding the implementation of digital twin, reports, and academic articles aimed at identifying best practices.

3. Literature review

The fathers of Digital Twin technology are Michael Grieves and Nick Vickers, who introduced the in a presentation at the University of Michigan in 2002 entitled “Conceptual Ideal for PLM” . In Grieves and John Vickers' understanding, virtual product representations were seen as "...relatively new and immature," and the data collected about physical products as "...limited, manually collected, and mostly paper-based." Grieves and Vickers envisioned a world where a virtual model of a product would provide the foundation for product life-cycle management [4].

In the work ”Digital Twin: Manufacturing Excellence through Virtual Factory Replication" (2014)”, Grieves expands on this definition by describing the Digital Twin as consisting of three components: a physical product, a virtual representation of that product, and the bi-directional data connections that feed data from the physical to the virtual representation, and information and processes from the virtual representation to the physical [4].

Digital Twin was defned from a model-focused perspective in 2012 by NASA as a multi-scale integrated simulation of a physical equipment or physical system that makes full use of virtual models, real-time sensor data, and historical data to map the entire life cycle process of the equipment or system [5].

Digital Twin technology is strongly correlated with multiple technologies, such as:

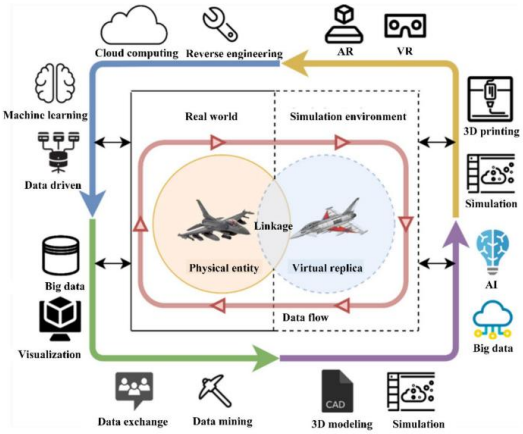

Fig.1. Digital Twin and related technologies
Source: [5]

Jun-Feng et al., in the paper "Systematic Review of Digital Twin Technology and Applications," have systematized the evolution of Digital Twin technology as outlined below:

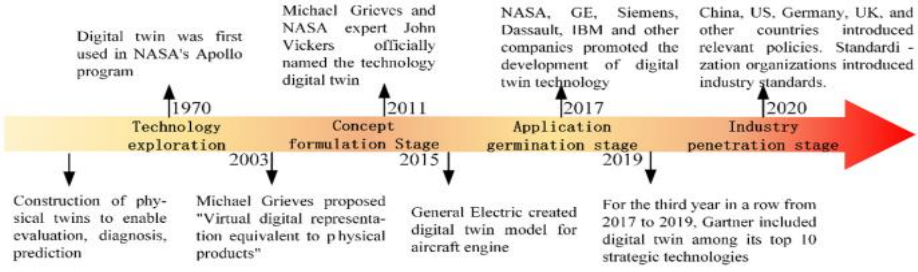

Fig.2. The evolution of Digital Twin
Source: [5]

In the definition provided by the European Commission in 2022, Digital Twins creates a virtual replica of a physical product, process, or system. The replica can, for example, predict when a machine will fail based on data analysis, which allows for increased productivity through predictive maintenance [6].

In the paper ”Mapping EU-based LDT providers and users” elaborated by European Commission, a Local Digital Twin is defined as a “virtual representation of the physical assets, processes, and people within a geographically located community, which reflect and derive from crosssectorial, historical and (near) real-time data. Its purpose is to enhance evidence-based decisionmaking, at the operational, strategic, and tactical levels, to better meet the needs of communities. LDTs combine multiple technologies, such as data analytics and artificial intelligence, enabling predictive and simulation models that can be updated and changed as their physical equivalents change. It must be made clear that this definition is not static and shall encompass future technological and structural changes” [7].

This research by the European Commission highlighted that a total of 135 platforms relevant to the LDT context were identified, covering 25 out of the 27 EU Member States, despite considerable cross-country differences.

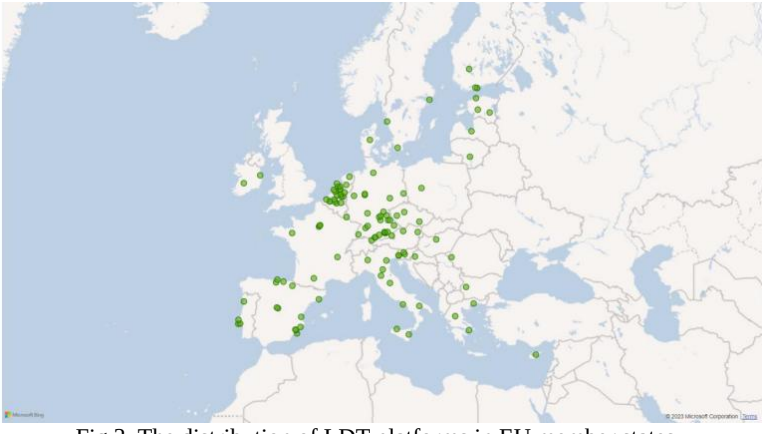

Fig.3. The distribution of LDT platforms in EU member states
Source: [7]

The conclusions of the report "Mapping EU-based LDT Providers and Users" highlight the following discrepancies in how LDT technology is utilized among member states:

- The current understanding of LDTs is not consistent across the EU, as the concept is frequently linked to 3D models of the physical infrastructure of a city or community;
- The adoption and development of LDTs take three distinct strategic directions: the data-first approach, the visualization-first approach, and the single-use case approach;
- The adoption of LDT platforms in the EU reflects a diverse and uneven geographical distribution, with a significant concentration in Western Europe;
- Developments of LDT platforms mainly occur at the city level, with only a limited number of instances found in rural areas and at the regional level;
- Numerous EU LDT platforms aim to enhance decision-making through the integration of simulation capabilities, yet none possess the self-learning functionalities that are crucial for an Intelligent or Cognitive Twin [7].

4. Europe's digital twins

4.1. Barcelona

On march 2023, Barcelona City Council and Barcelona Supercomputing Center released a web platform for analysing the accessibility of public facilities that makes it possible to assess if Barcelona complies with the provision of services or facilities of the so-called 15-minute city model.

According to Eurocities, an analysis of the Barcelona supercomputer centre has showed that, while improving air quality, superblocks have also increased pollution in adjacent areas where traffic has been displaced. In this way, digital twins' technologies have permitted to evaluate the impact of urban policies, correcting them while being

implemented. The city of Barcelona is also revolutionizing its urban planning through the 15-minutes city [8].

4.2. Flanders region duet digital twins

Flanders is a network of interrelated cities forming together with Brussels a large metropolis area. According to their website, the digital twins goals of the project are:

- Creating a Smart Region where all players can access available services and data;
- Support cross-silo cooperation between sectors;
- Involve citizens and companies active in policy-making processes to improve the quality of decision making and acceptance of the outcomes;
- Setting up transferable services and data standards to maximise efficiency and open the market. [9]

DUET Digital Twins provide virtual city replicas which make it easy to understand the complex interrelation between traffic, air quality, noise and other urban factors. Powerful analytics model the expected impacts of potential change to help you make better evidence-based operational decisions and longer term policy choices.(idem)

4.3. Digital twin Munich

To support its digital twin infrastructure, the city has created a collaborative environment with a dedicated core team and project group that work together to lay the foundations for these technologies. The city also emphasizes the importance of building strong partnerships with universities and research centers, recognizing that these collaborations are key to driving continuous innovation in digital twin projects [8].

4.5. Stockholm digital twin for citizen engagement

The Digital Twin of Stockholm has emerged as an impressive example of citizen engagement in urban planning and design. With ambitious goals to build 140,000 new apartments by 2030, the city recognized the need to involve residents from the very beginning. By harnessing the power of 3D visualization, Stockholm has created a photorealistic digital replica of its metropolitan area, which acts as a robust platform for communication and collaboration. This immersive experience allows residents, stakeholders, and potential investors to visually understand the development plan, promoting transparency and openness.

This initiative illustrates how Digital Twin technology can facilitate dialogue by employing web and mobile-based platforms to collect public input and capture a diverse range of opinions [10].

5. Benefits of the digital twin technology

Digital twin technology is increasingly being adopted across different industries and public services in Europe. The integration of digital twin technology aligns with the EU's broader goals articulated in the "2030 Digital Compass." By fostering a digitally skilled population, developing robust digital infrastructures, and enhancing the digital transformation of businesses and public services, digital twins can play a vital role in achieving these aspirations. The Strategic Foresight Report 2022, “Twinning the green and digital transition

in the new geopolitical context", reveals the very important role of digital twins technology to facilitate innovation, testing and the design of more sustainable solutions, e.g. in buildings or urban planning [2].

According to the report, digital twin technology:

- will improve systems process design, test new products and select optimal materials;
- could change the way urban spaces are planned, monitored, and managed
- could enhance planning, monitoring and management of urban spaces. It could also translate in reduced urban emissions, increased resource efficiencies and quality of life, increasing the resilience of buildings;
- will provide data to manage the diversification of products and use functional biodiversity to redesign pest control [2].

European Commission in the paper "Digital Twins-Integrated Planning Factsheet (2021), highlights the benefits for the citizen of the implementation of digital twin technology:

- digital twins help simplify complex concepts like energy efficiency and sustainability, making them easier for both practitioners and non-practitioners to understand and support;
- digital twins allow users to intuitively explore and visualize data in formats like 2D, 3D, and GIS that reflect the real-world city;
- digital twins can identify co-benefits for property owners, users, and urban infrastructure. For example, upgrading a public space while also adding solar panels to roofs can deliver multiple benefits;
- digital twins foster collaborative planning, enabling stakeholders to work together more effectively [3].

6. Challenges of the digital twin technology

The report, "Engaging twins" presents the work of the Eurocities taskforce on digital twins. The Eurocities taskforce on digital twins identified three main challenges to the adoption and implementation of digital twins:

- creating synergies and connecting with citizens;
- use of data and technical issues;
- governance and management issues [8].

The three main challenges identified by Eurocities refer to the ability of infrastructures to be modeled and supported by a supercomputer and/or other resources such as finances and funding. On the other hand, the most important issue concerns the transfer of high-quality data, an aspect that can be addressed through data interoperability. Another issue is citizen participation and the use of digital twin platforms, specifically addressing the problems of user-friendliness and accessibility.

According to Abayadeera and Ganegoda, "privacy concerns, data infrastructure integration, and scalability regarding digital twin technology are critical hurdles despite the transformative potential of enhancing urban planning". Authors consider that the

technology offers ”a wide range of applications, but challenges in infrastructure integration limit widespread adoption”. [11]

5. Conclusions

Digital twin technology is emerging as a critical tool for advancing sustainable urban development and improving city management across Europe.

However, to fully leverage the potential of digital twins, Europe must address several challenges:

- infrastructure and data issues(building the required infrastructure, such as supercomputers and funding, is a significant hurdle);
- citizen participation(engaging citizens in the digital twin process and making these platforms user-friendly and accessible remains a major challenge);
- privacy and integration.

To overcome this challenges, European cities and governments can foster collaborations with private tech companies, universities, and research institutions, that can help with the necessary infrastructure, such as supercomputing resources, data centers, and advanced hardware for processing real-time data from the digital twin systems.

On the other hand, it is vital to ensure interoperability between digital twin systems across different cities and sectors and for that European Union has to establish clear data standards and frameworks for the open data. To address the citizen participation a solution can be to provide digital literacy campaigns that can focus on educating citizens about how digital twin technologies work, how to access the platforms, and how their data is being used to improve their environments.

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Learning Management Systems (LMS): Optimizing education with PowerSchool and ManageBac, transforming learning and communication

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Abstract
Nowadays, education has evolved into a broad, challenging, and simultaneously progressive field. It is advancing alongside the rapid development of technology, which plays an essential role in transforming the way educators, students, and parents interact within the school environment. Specifically, Learning Management Systems (LMS) have become crucial in facilitating communication, engagement, and the efficient management of educational processes. The aim of this paper is to explore the role and significance of LMS platforms, particularly PowerSchool and ManageBac, and to examine how their features contribute to the academic success of students. PowerSchool is a comprehensive platform designed for K-12 schools that enhances personalized instruction, communication, and data management. Its integration of learning tools, assessments, grading systems, and reporting features allows educators to make data-driven decisions. PowerSchool also empowers parents by providing real-time access to student progress, assignments, and grades, fostering ongoing collaboration and ultimately promoting student success. Similarly, ManageBac is the preferred LMS for schools implementing the International Baccalaureate (IB) program, offering an integrated solution for curriculum planning, assessments, attendance tracking, and behavior management. It enables teachers to design personalized learning pathways, track student performance in real time, and seamlessly communicate assessment tasks, deadlines, and academic progress. Both platforms, widely used in international schools (including Albanian College Durrës), underscore the growing necessity for LMS adoption by all stakeholders in education. By centralizing critical data and improving access to real-time information, these platforms not only streamline educational processes but also create a more engaged, transparent, and collaborative learning environment that benefits students, teachers, and parents alike.

Keywords: Assessment, Data, Curriculum Planning.

1. Introduction
This article examines the crucial role of Learning Management Systems (LMS) in modern education, focusing on PowerSchool and ManageBac. As technology transforms education, adopting LMS platforms has become essential for schools to enhance communication, boost engagement, and streamline processes. The article highlights the unique features of these platforms that facilitate personalized instruction, real-time performance tracking, and improved communication among educators, students, and parents. It also explores the challenges associated with implementing these systems and provides guidance on the considerations schools should take into account when choosing between PowerSchool and ManageBac. Additionally, it emphasizes how these platforms support data-driven decision-making and promote student success, illustrating the significant benefits of LMS integration in today's educational landscape.

2. Literature review

The integration of technology in education has significantly transformed the learning experience, reshaping interactions between students, teachers, and parents. Learning Management Systems (LMS) have emerged as an important tools that facilitate curriculum management, communication, assessment, and personalized learning. An LMS creates an inclusive digital environment where academic progress can be monitored, collaboration can be facilitated, and instructional content can be efficiently managed [1]. According to [2] Nasser, Cherif, and Romanowski, LMS usage ensures that students receive consistent performance feedback, fostering their independence [3]. Engagement is further strengthened as students leverage these platforms to track their progress and stay informed [4].

An LMS provides a framework for various learning activities and supports the distribution and management of pedagogical content [5]. By offering specialized tools for tracking academic progress, managing assignments, and communicating announcements, LMS platforms create environments conducive to engagement and achievement [4]. Selecting an LMS can be challenging for schools, which must decide between proprietary and open-source systems [6]. The choice often depends on available resources and the expertise of the school staff [7]. A proprietary system, such as PowerSchool, requires schools to purchase a subscription or license, offering an integrated suite of tools with strong support and security features [8]. Criteria for evaluating LMS platforms include their impact on the student learning experience, teacher effectiveness, technology requirements, and sustainability.

LMS adoption can lead to improved academic outcomes by facilitating interactive learning, real-time feedback, and personalized instruction. Studies have shown that LMS platforms support data-driven decision-making, enabling teachers to adapt their strategies based on student performance and identify learning gaps [9]. During periods of remote or hybrid learning, LMS platforms have demonstrated their value by providing equitable access to educational resources [10].

3. Methodology

In this study, we used comparative analysis methodology to evaluate two school important Learning Management Systems (LMS), PowerSchool and ManageBac. This approach involved a short review of relevant literature that explores the impact of LMS platforms on teaching, learning, and administrative practices. The analysis incorporated a case study, such as the use of PowerSchool at Albanian College Durrës, by demonstrating practical applications of these LMS platforms.

Our methodology included the identification and evaluation of key functional areas for each LMS, specifically curriculum planning, assessment management, data accessibility, and user experience. The comparative analysis aimed to offer schools a comprehensive insight into how these LMS platforms can support their strategic objectives, addressing practical considerations, integration challenges, and their potential to enhance student engagement and academic success.

4. Powerschool

PowerSchool is a widely used LMS specifically designed for K-12 education, with a reputation for supporting educators, streamlining administrative tasks, and fostering communication. Its comprehensive suite of tools makes it an essential platform for schools seeking to enhance teaching practices and operational efficiency. One of PowerSchool's main strengths is its student information system (SIS), which enables educators to track student attendance, grades, and other critical data in real-time [5].

This centralized data system helps teachers make informed decisions about instructional strategies, ensuring that learning plans are tailored to student needs. The gradebook feature is particularly noteworthy, allowing teachers to record and monitor assessments, providing insights into student progress and areas where additional support might be needed [11]. PowerSchool also includes assessment management tools, which facilitate the design and administration of tests, helping educators evaluate student understanding and retention. This functionality promotes better tracking of academic progress and identification of trends that can inform teaching strategies.

Communication is another area where PowerSchool excels. Through integrated messaging and a dedicated parent portal, parents can access their child's academic information, view assignments, and receive notifications about school events. This transparency encourages parental involvement, which research has shown is a significant factor in student success [12]. PowerSchool's detailed reporting tools allow educators and administrators to create customized reports on grades, attendance, and behavior. These reports support targeted interventions and help schools monitor instructional effectiveness [13].

Furthermore, PowerSchool's ability to support personalized learning is a key advantage. Teachers can create custom lesson plans and educational materials tailored to different learning styles and paces. This level of personalization ensures that all students can achieve their potential, creating a more inclusive educational environment. PowerSchool offers numerous benefits for K-12 institutions. The platform's ability to provide real-time data and resources has been shown to enhance student engagement and academic outcomes. The communication tools embedded within the system facilitate collaboration between parents and educators, creating a transparent and supportive learning environment [14].

Despite its benefits, PowerSchool has some challenges. Technical problems like integration issues or system glitches can make it harder to use. Also, because it is a complex system, teachers who are not familiar with LMS platforms may need time to learn how to use it effectively. Proper training and support are important for teachers and administrators to fully take advantage of what PowerSchool offers.

5. ManageBac

ManageBac is an LMS designed for schools using the International Baccalaureate (IB) program, offering specialized tools for curriculum planning, assessment management, and real-time performance tracking. It helps teachers organize lessons, maintain curriculum consistency, and support student development. The platform also promotes collaboration

and communication among teachers, students, and parents, creating a supportive and transparent learning environment.

Founded in 2006, ManageBac is the leading online planning, assessment and reporting platform for over 3,000 IB World schools and the trusted choice of 4 in 5 IB Diploma students. By providing schools with one unified system on a consistent, modern and mobile-ready interface, ManageBac offers a seamless & integrated experience for coordinators, teachers, students and parents to manage all aspects of the IB programme [15].

With ManageBac, educators can design lesson plans that align with IB standards, which focus on interconnected learning and inquiry-based education. This ensures that the curriculum stays consistent across different subjects and grade levels. It also offers both formative and summative assessment tools, allowing teachers to monitor student progress, give feedback, and address any learning gaps effectively.

ManageBac's real-time tracking tools provide teachers with important insights into student performance, helping them make data-driven decisions and adapt their teaching to meet different learning needs. The platform's communication features make it easier for teachers, students, and parents to stay connected, share assignments, deadlines, and feedback, and improve engagement. ManageBac also has detailed reporting tools that create custom reports on student performance, attendance, and engagement, which help schools align their teaching with the IB program's goal of fostering critical thinking and a well-rounded education.

However, ManageBac does have some challenges. It has a learning curve that may require substantial training for staff, which can take time and resources for professional development to use the platform effectively.

6. ManageBac vs. PowerSchool: which LMS is right for my school?

ManageBac is an LMS made for schools using the International Baccalaureate (IB) program. It supports lesson planning, assessment management, and communication between teachers, students, and parents, aligning with the IB's focus on inquiry-based learning. However, ManageBac does not function as a full Student Information System (SIS), making it less suitable for schools that need complete student data management.

PowerSchool, on the other hand, serves as both an LMS and SIS, making it ideal for a wider range of schools, including K-12. It handles everything from student demographics and attendance to grading and assessments. This all-in-one system saves time, improves efficiency, and helps schools manage various administrative and academic tasks in one place. Albanian College Durres, an International School following AERO standards, uses PowerSchool as its student information system. PowerSchool offers comprehensive cloud-based solutions for K-12 schools and districts, connecting the central office, classrooms, and homes to support student success [16]. Its tools help streamline administration, enhance

communication, and ensure that educators, students, and parents stay informed and engaged.
ManageBac is great for planning lessons and tracking student progress, which supports the IB's standards. However, schools may struggle with accessing complete student data, such as attendance and demographic information, as ManageBac lacks SIS features. This may require additional software, leading to extra work.

PowerSchool's combined LMS and SIS features mean that all student data can be accessed in one place, helping educators make better decisions and support students more effectively. Its easy-to-use interface also allows parents to track their child's grades, attendance, and assignments, encouraging greater parental involvement, which can improve student outcomes. ManageBac, while functional for teachers and students, can be harder for parents to navigate.

PowerSchool also stands out for its ability to integrate with other systems, making data sharing seamless and workflows more efficient. In contrast, ManageBac often requires schools to use extra tools for things like attendance and student records, which can create inefficiencies.
As mentioned above, we can briefly summarize the benefits and challenges of each platform:
ManageBac's Benefits:

- Tailored specifically for IB schools, aligning with the program's educational standards.
- Strong curriculum planning and assessment management tools.
- Real-time performance tracking and detailed reporting for educators.
- Enhanced communication between teachers, students, and parents.

ManageBac's Challenges:

- Limited functionality as it does not function as an SIS.
- Schools may need additional systems for comprehensive data management.
- Learning curve for educators to become proficient with the platform.

PowerSchool's Benefits:

- Comprehensive system that integrates LMS and SIS functionalities.
- Centralized data management for ease of access and efficiency.
- User-friendly interface that supports parent engagement and involvement.
- Compatibility with various educational tools for seamless workflows.

PowerSchool's Challenges:

- Can be more complex to set up and manage due to its wide range of features.
- Schools may need training and professional development to fully utilize the system.
- Data security and privacy concerns must be carefully managed.

7. Conclusion

Both ManageBac and PowerSchool offer unique benefits suited to different school needs. ManageBac is a great choice for schools using the IB program due to its strong focus on curriculum management, assessment tracking, and communication. On the other hand,

PowerSchool is better for schools that need comprehensive data management, as it combines LMS and SIS functions, offers seamless integration, and provides a better user experience for parents.

The choice between ManageBac and PowerSchool depends on the school's specific needs. ManageBac is best for schools looking for an LMS that aligns with IB standards, while PowerSchool's all-in-one approach is more suitable for schools needing an integrated platform to handle various aspects of student information and administration.

8. Recommendation

To get the most out of LMS platforms, schools should keep up with new technology and use these tools in ways that support teaching methods. School leaders should work with teachers to make the best use of LMS features and promote active learning. Teachers should follow curriculum guidelines and balance using technology with student-centered learning. By finding this balance, schools can create an engaging and effective learning environment that helps students succeed and grow.

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Beyond commands and queries: Exploring smart speaker utilization in Romania's domestic environments

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Abstract

Smart speakers have spread faster than smartphones, becoming popular worldwide. In Romania, despite the fact that these devices are not directly sold and Romanian is not available in the language menu, they have gained popularity among technology enthusiasts, particularly those passionate about voice technologies and smart homes. Drawing on repeated conversations with Romanian users of smart speakers conducted between 2020 and 2022, as well as 300 comments collected from local e-commerce sites (such as Emag.ro and OLX.ro) and online platforms (YouTube, Change.org), I analyzed how these users navigate language limitations, adopt these devices, and integrate them into their daily routines. By examining Romania's computing history, I identified a techno-vernacular approach to computational devices that helped me understand how Romanian users interact with these devices through what I call language hacking practices. The focus on language, the most sensitive aspect highlighted by my respondents and online commenters, became the catalyst for this research, opening new avenues of analysis. Beyond being conversational devices, smart speakers can be used in diverse ways. Concepts such as genre repertoire and usage genres helped me highlight how actual usage occurs and how users integrate these devices into their established media repertoires. Understanding the media ideology of these users was essential to deconstruct their views on newness and remediation, as well as their perspectives on delicate but pertinent subjects such as algorithms and privacy. Particularly important in the context of smart speakers is the discussion about privacy and surveillance, given that these devices have potent microphones and are always in listening mode. This brings to the forefront delicate discussions about privacy within the most private space—the home. Moreover, beyond the dialogue with the devices, the management of the household through commands, automation, and the integration of other smart devices to create a smart home, smart speakers are producing significant changes within the domestic space. These changes are visible in the domestic soundscape, the experience of the space itself, the relationships between family members, the gender divide highlighted by the emergence of new roles within the household, and the redistribution of parental roles with children.

Keywords: conversational devices, smart home, Global South.

1. Introduction

Smart speakers adoption worldwide has attracted attention from early 2018 after they have been launched in the US by Amazon and later Google. Users that were previously actively using Siri on iPhone or Google Voice Assistants on Android smartphones were keen into exploring the new devices that were promising the transformation of their homes into smart homes. These devices designed and built on the North American continent were built initially for the English speaking markets, US and Canada, only after being tested by users in these markets they have been released in other countries from Western Europe (France, Italy, Germany, Spain) or Asia. The initial moments that surrounded the emergence of these devices is one of particular importance and it represented the starting point of my research. My focus is Romania and Romanian users of smart speakers that are operating in a national context in which these devices are not being sold directly on the market and the Romanian language is not available in the language menu. In this paper, I will begin with an overview of the history of smart speakers, followed by a concise presentation of four key topics that emerged from my ethnographic research with Romanian smart speaker users conducted between 2020 and 2022. By organizing the content into distinct sections, I aim to enhance

the reader's comprehension of the primary insights derived from my interviews and content analysis.

2. What are smart speakers?

Voice-controlled technologies, in which smart speakers are included, are not new; historically they trace back to the voice assistants developed by IBM (1961) and Microsoft (1990) and to the smart homes projects created at Massachusetts Institute of Technology (1990), Georgia Institute of Technology (1997), and Interactive Institute Project (1999).
The initial voice assistants had no conversational abilities and they just offered support to users in certain environments - IBM Shoebox could understand 16 words and was able to perform mathematical functions and perform speech recognition, while Clippy from Microsoft had a primitive artificial intelligence and was able to offer editing and reference support for those writing in Microsoft Word. The era of the new voice assistants started with Siri (2010), continued with Microsoft Cortana (2014) and Google Assistant (2016) and culminated with Alexa Echo (2014) and Google Home (2016). Compared to the first voice recognition devices, current voice assistants have a computational system connected to the Internet [1], while also being equipped with sophisticated voice recognition systems and artificial intelligence.

Known by several names - intelligent voice-controlled assistants, voice-controlled personal assistants [2], smart speakers [3] and conversational agents [4], voice assistants can be of two types, smart speakers that work via Bluetooth - Amazon Echo, Google Home - or software that works on computers or smartphones - Cortana from Microsoft, Siri from Apple.

The new developments of voice technologies enable them to respond verbally quickly, thus eliminating any manual operation; for example, users can turn on the smart speakers only by saying their name - “Alexa”, “Hey, Google”, while artificial intelligence enables them to answer questions, like “What day is today?”, “What is the meaning of life”, “What team won the football game?”, to offer expanded answers and to conduct conversations. In my research, I primarily refer to these devices as “smart speakers”, a term that aligns with the nomenclature used by leading companies like Google and Amazon in their marketing efforts, and is also how my respondents commonly refer to them.

As mentioned above, the new generation of voice technologies do not mark only the technological development of this specific technology - “the third wave of technology” as named by Weiser - but they also highlight the return to the universe of apartments and smart homes [5]. Initial smart home projects were aimed at enhancing home comfort through technological integration. Smart home concepts from the 1940s to the 1960s were often linked to the idea of freeing women from the labor-intensive tasks traditionally associated with the kitchen. However, these visions tended to overlook the myriad other household chores that women were expected to perform. The era was epitomized by the “kitchen debate” of 1959, where Richard Nixon and Nikita Khrushchev’s exchange portrayed the United States’ future as an advanced “kitchen of tomorrow”.

Yet, this futuristic outlook failed to address the full spectrum of domestic labor, such as sweeping, washing, vacuuming, and tidying up, which also contributed to women's domestic responsibilities. An intriguing case in the history of smart home innovation is Frances Gabe's self-cleaning house, for which she received a patent in 1984. Her work, along with that of other pioneering female engineers such as Lillian Gilbreth, Christine Frederick, and Ellen Richards, represents significant advancements in the smart home space. These women's involvement in the early development of home automation is particularly noteworthy given the subsequent hiatus of such projects due to high costs and impracticality at the time.

Today, as smart home technologies resurface and evolve into the sophisticated systems we recognize, they are predominantly driven by corporate entities with a workforce heavily skewed towards male engineers. Despite this, the historical and ongoing contributions of women engineers to the fields of house cleaning devices and smart technologies have been - and continue to be - largely underrecognized. While the initial wave of smart home projects may have stalled, the concept did not vanish. Instead, it persisted within communities of smart home enthusiasts, such as IOC (Human-Computer Interaction), CU (Ubiquitous Computation) and AI (Artificial Intelligence) communities, quietly evolving until it caught the attention of major tech corporations. It was the intervention of industry giants like Google and Amazon that brought smart home technologies into the limelight once again.

The resurgence of smart speakers is often linked to the broader concept of the Internet of Things (IoT), which refers to the network of interconnected and uniquely identifiable computing devices embedded within everyday objects. The IoT extends beyond the confines of individual households, finding applications on a larger scale in the development of "smart cities". Within the domestic environment, where smart speakers, smart lights, smart locks, and other connected devices are commonplace, the term "smart home" is more aptly used to describe this interconnected ecosystem (*Idem*).

In my research, "smart home" will be the term consistently employed across all chapters to refer to the domestic implementation of IoT technologies. Furthermore, the focus of my ethnographic research is represented by the smart speakers produced by Google and Amazon, specifically the Alexa Echo/Echo Dot and Google Home/Google Nest product lines. These devices have been central to my study, providing a window into the integration of smart technologies into Romanian homes and the lived experiences of their users.

As stated by Amazon, Alexa Echo started to be developed inside Lab16 offices in Silicon Valley, California and Cambridge, Massachusetts in 2010 and was created with the initial purpose to expand the company's portfolio beyond Kindle e-reader. Another explanation offered by the company to motivate the Alexa Echo creation was the desire to reinvent the conversational computer onboard Star Trek's Starship Enterprise (VentureBeat, 2017). Since Alexa Echo was the first smart speaker created, I speculate that this explanation and reference to the iconic TV series was meant to create buzz around the device, mystify the object and stimulate the consumer's curiosity for this type of device.

The first-generation Echo was limited to Amazon Prime members or was possible only through invitation (a common marketing tactic), but it became available across the United States in 2015. Alexa Echo was designed initially as a simple speaker, but as the artificial intelligence, Alexa, evolved, the device became a controlling center for smart home appliances. The transition to a hub was influenced by the affiliation of companies that wanted to collaborate with Amazon and integrate their services to Alexa Echo. Now Alexa Echo reached its' fifth version in 2022, services and skills are continuously being added and are made accessible in the markets where they are sold directly, USA, Canada, Western Europe.

Amazon's main competitor in terms of smart speakers, Google, framed the creation of Google Home in direct response to Alexa Echo. Google Home, officially launched in 2016, was running Google Assistant as the basis for the smart speaker. Similar to Alexa Echo, Google Home was launched initially in the USA, but, faster than its competitor, launched the device in other countries - UK, Australia, Canada, France, Germany, Japan (2017), Denmark, South Korea, Mexico, The Netherlands, Norway, Spain, Sweden (2018). Part of Google's strategy was to offer access to a variety of consumers and languages as they declared in public press releases and conferences, while Amazon was more focused on the USA market and its consumers. As Google developed more products for the smart home and for the creation of a smart ecosystem within their brand they changed the name of the smart speakers from Google to Google Nest.

Apart from the multitude of device variations, services and functions offered, and apps integrated, both smart speakers offer users the possibility of personalization and customization that their predecessors didn't have. Both Alexa Echo/Echo Dot and Google Home/Google Nest allow their users to have a level of involvement and control - over the device. In the Amazon environment the personalization option comes under the name of "Alexa Skill Blueprints", while Google doesn't label it in any way. Diving into the history of voice technologies, their evolution in time and resurgence after a hiatus of over 50 years, is essential for understanding better smart speakers as technology devices.

From the early days of personal computing to the advent of the smartphone, each leap forward in hardware and software has brought us closer to the seamless, natural language interactions we have with devices today. The introduction of Siri on the iPhone 4S marked a pivotal moment, signaling the transition of voice assistants from novelty to necessity. This evolution continued with the emergence of a variety of voice-activated digital assistants from tech giants, each contributing to the rich diversity of the Internet of Things and the smart home. As I reflect on this journey, it becomes evident that voice assistants are more than just a convenience; they represent a fundamental shift in the way we interact with technology.

3. Methodology

My research explores the adoption and use of smart speakers in Romania, a market where these devices lack direct sales and native Romanian language support. The study aims to understand how Romanian users overcome these challenges, integrate smart speakers into their daily lives, and devise creative solutions to language and market limitations.

The research addresses six main questions:

1. How Romanian users of smart speakers are navigating the language limitations?;
2. What specific practices do Romanian users adopt when interacting with smart speakers?;
3. What affordances do Romanian users of smart speakers leverage within their homes?; 4. How is smart speakers' usage being perceived in terms of benefits and threats?;
5. How are smart speakers perceived in connection with privacy and surveillance?;
6. What impact does the introduction of smart speakers have on Romanian households?.

Conducting this study during the COVID-19 pandemic presented unique challenges, requiring a shift to digital platforms for interviews and data collection. I pivoted to an online methodology, drawing from the field of digital anthropology to conduct interviews via Google Meets and perform content analysis of user comments on e-commerce websites like Emag.ro and OLX.ro, as well as digital platforms such as YouTube.

This shift aligns with the broader trend of "netnography" [6] a digital form of ethnography used to study online communities and digital behaviors. My research contributes to digital anthropology by examining smart speaker adoption, usage patterns, and their integration into Romanian households, bridging disciplines like media studies and human-computer interaction.

Respondents are middle-class individuals aged 30-42 from Bucharest and Brașov, with diverse professions and high educational attainment. Data was collected through online interviews and observations of online forums and e-commerce platforms. Privacy concerns were evident, with some respondents reluctant to share visual aspects of their homes during interviews.

The study employs theoretical frameworks like "triple articulation" [7] and "in/from South" [8] to analyze user interactions and the geographical context of technology access.

The research highlights the importance of understanding digital comfort zones and privacy concerns in digital anthropology, offering insights into the integration of smart speakers in Romanian homes.

4. Navigating language limitation through translanguaging practices

In order to use smart speakers in a national context in which Romanian language is not supported, Romanian users adapt by using English, highlighting the dominance of English in technology. I introduce the concept of "translanguaging" [9]to indicate how users are navigating these limitations in a creative manner. This practice of building work-arounds around language is not particular only to Romania, but to other secondary markets that are not considered by the big technology companies. The language limitations that users from the Global South have to face emphasize the existing colonial mindset in technology design and the need for more inclusive language policies.

Specifically, to situate the usage of smart speakers among Romanian users I use the concept of "language hacking" [10, 11]. These practices can be connected to the historical hacking in Romania, tracing back to communism when hacking evolved from a necessity to a form of cultural expression. Today, hacking practices are more about penetrating into global markets and adapting technology to local needs.

Language hacking practices reveal the limitations of smart speakers for non-native English speakers. These practices are not just technical solutions but also reflect a techno-political ethos, showcasing the potential for customization within certain limits.

Romanian users employ cleverness and adaptability, known as "șmecherie" [12] to navigate these challenges. These practices foster social connections and democratize access to technology within households, creating new rituals and routines.

Moreover, the limitations around smart speakers are reflected into "quiet activism" [13, 14, 15, 16], forms of subtle resistance adopted by Romanian users advocating for Romanian language support in smart speakers. This activism is seen in online petitions and community discussions, space of "digital heterotopia" [17] where users come together to push for removing language limitations.

5. Content consumption through smart speakers in Romania

Despite language barriers and limited service availability, Romanian users manage to engage with smart speakers, capitalizing on the unique consumption activities that define the smart speaker experience to expand their digital personas. This engagement demonstrates the compelling nature of smart speakers, which manage to captivate users' interest and integrate into their digital lives, often standing out amidst a multitude of other devices. Among Romanian users, there are specific usage genres that are prominent, such as entertainment, news, dialogue, and commands.

Established "media repertoires" [18], such as prior experience with voice assistance, influence Romanian users' adoption of smart speakers, showing that this process expands users' overall media repertoire rather than replacing older media devices. The transition to consuming content via smart speakers changes the user experience, with sound quality and listening experience frequently emerging as central themes. This shift points to a broader media ideology discussion that emphasizes a return to orality and a move away from tactile digital interactions, while also introducing new elements such as algorithms.

The "media ideology" [19] in which Romanian users activate influences their beliefs about conversational devices, shaping their usage and interpretation of smart speakers.

Users adopt smart speakers in their day to lives, but they do not renounce to prior devices, constantly switching between smart speakers and smartphones, laptops and computers, depending on their needs. This switch expressed through the concepts of "remediation-newness" [20] are highlighting how smart speakers are redefining media consumption within households, steering it from an individualistic activity back towards a shared experience. This shift mirrors the communal engagement once fostered by the family

television moment, which had been eroded by the advent of personal computers, laptops, and smartphones.

Moreover, smart speakers facilitate a sense of connection and interaction, positioning themselves as a significant medium for communication, information, and consumption.

Conversational devices emphasizes a shift in auditory experiences and the emergence of new consumption practices termed “liquid forms” [21] characterized by their access-based, ephemeral, and individualized nature. These practices are facilitated by the functionalities of smart speakers, which act as interfaces to the Internet, enabling seamless integration of online services.

In the case of Romanian users, due to the high content consumption, algorithms became important for understanding how streaming platforms and technology companies are shaping user behavior and consumption patterns [22, 23]. Nevertheless, users are aware of algorithms existence and their influence, but perception about algorithms is influenced strongly by media ideology, more specific by pleasure in relation to comfort and entertainment and fear in relation to privacy and security of data.

6. Smart speakers, privacy, and the quest for balance

Discussions about privacy and security of data with smart speakers are prominent in the US and countries like France, Italy, Germany, and Spain, where local languages are supported. In North America, 70 million users, nearly a quarter of the American population, use these devices. In Europe, numbers vary, with 20 million users in the UK and 18 million in Germany. The global spread of smart speakers has accelerated the adoption of voice technologies and raised privacy concerns. These devices, equipped with sensors and microphones, continuously listen for activation words to execute user requests, raising privacy challenges due to their placement in homes and potential for data collection.

In North America, privacy issues with smart speakers have made headlines, revealing that companies like Amazon, Google, and Apple have used human contractors to review audio snippets, raising concerns about data storage and access. Some smart speakers have been hacked, highlighting security vulnerabilities. Concerns also exist about third-party developers creating skills or actions that could violate user privacy. These issues have led to public discourse on privacy, prompting companies to update their policies, allowing users to opt-out of certain data collection practices. In the US, privacy laws like the Electronic Communications Privacy Act and the Children’s Online Privacy Protection Act apply, while in Europe, the General Data Protection Regulation (GDPR) governs data collection and privacy.

Romania, as an EU member, aligns with EU digital regulations and has developed its own framework for personal data security. The 2018 e-Privacy Law introduced rights like “the right to be forgotten” and “the right to data portability,” empowering users to request information on data processing. Research shows Romanians are aware of privacy risks, with 25.5% preferring anonymity online and 24.9% occasionally declining cookies.

Despite openness to new technologies, Romanians are cautious about their digital footprint, reflecting a knowledge-based autonomy in privacy decisions.

Globally, privacy is interpreted differently, influenced by cultural, legal, and political factors. In Europe, privacy is highly regulated, while in North America, it is more fluid and state-dependent. Smart speakers, always in listening mode, raise privacy concerns due to their sensitive microphones and data storage capabilities. Perceptions of privacy threats vary, necessitating tailored discussions to reflect diverse geographical and cultural landscapes. In regions like the Global South, where smart speakers are not actively marketed, analytical frameworks from the Global North may be inadequate. Privacy awareness and practices differ among nations, with a growing understanding of algorithms related to personalization and customization.

Smart speakers collect two types of data: universal data, independent of the user's market, and functional data, dependent on market availability. Data collection mechanisms include user-provided information, automatic information from cookies, mobile information, email communications, and information from other sources. Privacy concerns arise from data mining, eavesdropping, and surveillance capitalism, highlighting the ongoing collection and exchange of information facilitated by digital technologies [24, 25]. The concept of "eavesmining" [26]describes the subtle extraction of information from domestic spaces by corporate entities, marking a new frontier in balancing convenience and privacy.

7. Exploring the influence of smart speakers on domestic space

The concept of home is constantly evolving with the integration of technology, such as smart speakers, which redefine our living spaces and alter the dynamics of domestic life.

These devices are introducing new modes of interaction, like voice commands, that blur the lines between public and private spheres and individual and collective experiences.

This chapter explores the nuanced concepts of domestic space, household, house, and home, using each term to highlight different aspects of living environments. By examining these concepts, the chapter aims to illustrate how smart speakers transform the spatial, managerial, functional, and emotional layers of domestic life, becoming an integral part of daily routines and rituals.

Smart speakers become woven into household routines, coordinating activities and shaping the ambiance of daily life. They facilitate routine and ritual, echoing the historical role of devices like televisions and radios. Smart speakers are assimilated into domestic spaces and reshape household operations and family dynamics impacting gender roles and family structures, redefining notions of control and care.

Through voice, sound and conversation, smart speakers are transforming the home into a dynamic acoustic ecosystem, a domestic soundscape [27]. Through constant usage, smart speakers are being domesticated and integrated into family life, being present in all its aspects. The resurgence of voice interaction through smart speakers marks a significant

shift in the domestic soundscape, redefining how activities are initiated and experienced within the home.

The concept of soundscape, linked to histories of mediation and technologies, explains the role of sound in creating social cohesion and emotional security. Smart speakers, with their voice-driven interfaces, become an integral part of aural tapestry, influencing the auditory experience of domestic life. In this new domestic soundscape smart speakers introduce new layers of interaction and enhance household management, creating a symbolic spatiality, forging auditory linkages that cultivate a unique sense of place within the home.

8. Conclusion

Smart speakers gained global attention starting in early 2018, following their US launch by Amazon and Google. Initially designed for English-speaking markets, these devices were later introduced in Western Europe and Asia. This marked the beginning of my research, focusing on Romanian users' experiences with smart speakers. My research addresses several questions: how Romanian users navigate language limitations, their interaction practices, the benefits and threats perceived, and the impact on households.

Using digital anthropology, I conducted interviews and analyzed 300 online reviews to gather insights into Romanian users' adoption and perception of smart speakers.

I explored the challenges Romanian users face due to the lack of Romanian language support, highlighting issues like communication barriers and limited access to services.

Theories from language anthropology and translanguaging studies helped me understand the power dynamics between companies and users. I argued that Romania, like other Global South countries, was overlooked by tech companies, despite having smart speaker users. Romanian users developed unique practices, not just technological workarounds, but strategies for overcoming limitations.

The concept of “language hacking practices” was central to my analysis, showing how users creatively adapted smart speakers. This customization, while promoted by tech companies, revealed limitations for non-dominant markets. Romanian users' cleverness and adaptability were evident in their use of smart speakers, reflecting a desire to align with Western standards. I introduced “quiet activism” to describe how users shared advice and supported Silicon Valley ideals through online platforms.

My research also examined the primary uses of smart speakers in Romania, such as entertainment and information. I used concepts from language anthropology and media studies to analyze usage practices, showing how smart speakers create new consumption forms and enhance user experiences. I highlighted how these devices redefine digital media consumption and influence privacy attitudes, introducing the concept of “eavesmining” to describe the novel surveillance challenges they pose.

In conclusion, I discussed how smart speakers transform domestic spaces into “domestic soundscapes,” influencing routines and rituals. I used the “triple articulation” framework

to understand their integration into Romanian households, revealing their impact on social and cultural dynamics. I also explored how smart speakers affect gender roles and children's interactions, emphasizing their role in digital housekeeping and socialization.

This study contributes to digital anthropology by offering a unique perspective on smart speakers in the Global South. It expands the understanding of these devices beyond the Global North's focus, addressing topics like privacy, domestic soundscapes, gender roles, and children's usage. These insights can inform future research on similar technologies.

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