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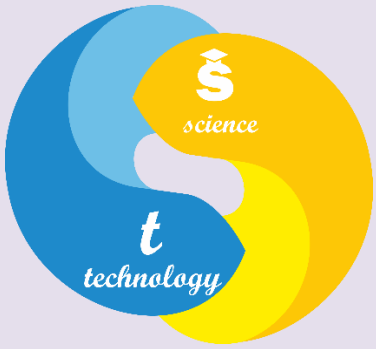

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«Modern Technologies: Improving the Present and Impacting the Future»

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Збірка містить тези доповідей Міжнародної наукової мультидисциплінарної конференції студентів і молодих учених «Modern Technologies: Improving the Present and Impacting the Future», яка відбулася 20 листопада 2025 р. в Українському державному університеті науки і технологій. Тези представлені англійською, німецькою, польською та іспанською мовами.
Для студентів, аспірантів, викладачів. Друкується в авторській редакції.

Maria Odarenko
Constantine the Philosopher University in Nitra, Slovakia

THE STRATEGIC NECESSITY OF DIVERSITY AND INCLUSION IN THE MODERN ORGANIZATIONAL WORKFORCE

In today's globalised and dynamic business environment, workforce diversity and inclusion (D&I) constitute fundamental strategic priorities for organisations aspiring to be progressive and resilient. An inclusive and diverse workforce not only mirrors the multicultural complexity of society but also stimulates innovation, creativity, and adaptability within organisations. Researchers confirm that companies that effectively embed D&I practices experience enhanced decision-making, higher employee engagement, and improved performance outcomes. According to Sage Advice (2024) summarising D&I benefits: inclusive teams make better business decisions 87 % of the time and reach those decisions twice as fast. They also hold fewer meetings and propose more effective solutions. A 2025 report by ZipDo Education found that companies with diverse leadership are 33 % more likely to financially outperform peers. Ethnic and cultural diversity in the top quartile correlates with 35 % greater likelihood of above-median profitability.

Workforce diversity encompasses varied dimensions of human difference, such as race, ethnicity, gender, age, sexual orientation, physical ability, and cultural background. Inclusion, by contrast, refers to creating conditions in which all employees feel respected, valued, and empowered to participate fully and contribute meaningfully to organisational goals. Many scientifical studies reveal that diversity alone is insufficient without concurrent efforts to foster inclusion; when inclusive practices are lacking, individuals from underrepresented backgrounds may continue to experience isolation and undervaluation despite diverse representation.

Developing robust D&I policies is critical for operationalising diversity and inclusion within the organisational culture. These policies serve as the structural framework guiding leadership behaviours, HR practices, and workforce norms. Organisations should begin by articulating clear D&I objectives aligned with their mission and values, and incorporate procedural mechanisms such as blind recruitment, equitable performance criteria, and measurable diversity milestones.

Beyond recruitment, effective D&I strategies extend across compensation, career progression, and representation. It is essential that organisations conduct regular audits to detect disparities in pay, promotional pathways, and access to opportunities. These audits foster transparency and promote trust among employees, thereby enhancing retention and cultivating an inclusive organisational climate.

Training and education are pivotal to operationalising D&I. Comprehensive diversity training initiatives can raise awareness of unconscious bias, cultural dynamics, and inclusive practices, thereby equipping employees and managers to engage more effectively across differences. Training must be complemented by leadership development in inclusive management, as executives set the tone and model inclusive behaviours for the entire workforce.

Empirical evidence underscores that organisations committed to diversity and inclusion enjoy elevated employee satisfaction, reduced turnover, and stronger employer branding. When individuals perceive that their contributions are valued and that they belong, engagement and productivity increase significantly. Hence, prioritising diversity and inclusion is not only a moral imperative but a strategic necessity for organisations seeking to maintain competitiveness, innovation, and resilience in today's complex business landscape.

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DIE EINFÜHRUNG KÜNSTLICHER INTELLIGENZ

Die Einführung künstlicher Intelligenz schreitet rasant voran, und das ist erst der Anfang. Dies verändert grundlegend die Herangehensweise an die Entwicklung digitaler Lösungen sowie die Art und

Weise, wie Unternehmen mit ihren Kunden interagieren, ihr Geschäft ausbauen und Innovationen einführen.

Künstliche Intelligenz ist eine Technologie, die es Computersystemen ermöglicht, menschliches Denken zu imitieren. Sie können Informationen analysieren, aus Erfahrungen lernen, fundierte Entscheidungen treffen und Prognosen erstellen. KI basiert auf Algorithmen, die große Datenmengen verarbeiten, Muster erkennen und ihre Leistung kontinuierlich verbessern können.

Maschinelles Lernen (ML) – eine Technologie, die Systemen dabei hilft, Datenmuster zu erkennen, Erkenntnisse zu gewinnen und auf der Grundlage der gewonnenen Informationen zu lernen.

Deep Learning – eine Unterart des ML, die die Funktionsweise des neuronalen Netzwerks des menschlichen Gehirns nachahmt und die Verarbeitung komplexer, vielschichtiger Datenstrukturen ermöglicht.

Neuronale Netze – ein grundlegender Bestandteil des Deep Learning. Sie bestehen aus miteinander verbundenen Ebenen – Eingangs-, versteckten und Ausgangs-Ebenen –, durch die Informationen fließen und sich auf der Grundlage von Rückmeldungen ständig verbessern.

Generative KI – eine separate Kategorie, die auf der Grundlage bereits vorhandener Informationen neue Texte, Bilder, Töne, Codes und andere Daten erstellt. Beliebte Tools wie ChatGPT demonstrieren die Möglichkeiten dieser Technologie, aber ihr Anwendungsspektrum ist viel breiter.

Der Markt für künstliche Intelligenz verändert sich täglich – es kommen neue Tools hinzu, und die bestehenden werden präziser, flexibler und funktionaler.

ChatGPT ist ein Sprachmodell, das auf die Generierung und Verarbeitung von Text ausgerichtet ist. Seine Hauptaufgabe besteht darin, Antworten im Dialogformat zu erstellen. Dank mehrstufigem Training mit großen Textdatenmengen kann ChatGPT Texte mit einer logischen Struktur entsprechend dem Kontext erstellen.

Möglichkeiten:

Automatisierung des Kundensupports;
Erstellung von Marketinginhalten;
Verfassen von Texten, Drehbüchern, Zusammenfassungen;
Vorbereitung von Schulungs- und Trainingsprogrammen im Format interaktiver Sitzungen.

ChatGPT passt sich leicht an den Ton, den Stil und das Thema der Anfragen an, was dieses System für die meisten Aufgaben im Zusammenhang mit Textinhalten universell einsetzbar macht.

Gemini – ein multimodulares Modell mit Visualisierungsintelligenz. Gemini ist ein KI-System, das die Verarbeitung von Text, Bildern, Videos und anderen Datentypen in einem einzigen Modell vereint.

Funktionen:

Analyse von Multimedia-Inhalten;
Erstellung von Beschreibungen zu Videos oder Bildern;
Bearbeitung von Präsentationen, Berichten und komplexen Grafiken.

Der Unterschied von Gemini besteht in der Fähigkeit, mit mehreren Arten von Informationen gleichzeitig zu arbeiten. Dadurch kann es in komplexen Informationsprojekten eingesetzt werden.

Copilot ist ein Tool für Programmierer, das in Code-Editoren integriert werden kann. Sein Hauptzweck besteht darin, beim Schreiben von Programmen zu helfen. Die KI kann Vorschläge machen, den Code ergänzen und optimieren sowie Fehler aufdecken.

Möglichkeiten:

Beschleunigung der Softwareentwicklung;
Ausbildung von Programmieranfängern;
automatische Generierung von Codefragmenten;

Der Hauptvorteil von LLaMA ist die Verfügbarkeit des Codes und des Modells für Modifikationen, was umfangreiche Anpassungsmöglichkeiten eröffnet.

Mistral – kompakte und leistungsstarke KI für Agenten. Mistral ist ein Sprachmodell, das auf Geschwindigkeit und Effizienz der Berechnungen ausgerichtet ist. Trotz seiner relativ geringen Größe bietet es eine hohe Qualität der Textgenerierung.

Verwendet für:

eingebettete Systeme und Anwendungen;

die Erstellung kompakter Sprachagenten;
Projekte mit begrenzten Rechenressourcen.

Mistral – optimale Balance zwischen Leistung und Ressourcenverbrauch, was es für den lokalen Einsatz interessant macht.

Midjourney – KI zur Bilderzeugung. Midjourney – generatives Modell, das auf die Erstellung von Bildern spezialisiert ist. Der Benutzer formuliert seine Anfrage in Form einer Textbeschreibung, und das System generiert ein visuelles Ergebnis.

Möglichkeiten:
Konzeptkunst;
Design, Illustrationen und Rendering;
Entwicklung von Charakteren und Szenen.

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Technische Universität Wien
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INNOVATIVE NEUHEITEN IM BEREICH DER BAUTECHNOLOGIEN

Die unglaubliche Geschwindigkeit, mit der sich Wissenschaft und Technik entwickeln, beschert uns täglich Technologien, von denen wir früher nur träumen konnten! Die erstaunlichen Entwicklungen moderner Wissenschaftler begeistern und beeindrucken durch ihre Neuheit und Bedeutung. Es ist sehr erfreulich, dass die technologische Entwicklung auch unsere Bauindustrie betrifft. Heute erwartet Sie viele interessante Informationen über innovative Neuheiten im Bereich der Bautechnologien.

Vor einigen Jahren haben die größten und innovativsten Bauträger begonnen, das Building Information Modeling (BIM) einzuführen. Es basiert auf einem dreidimensionalen Informationsmodell, auf dessen Grundlage die Arbeit von Investoren, Auftraggebern, Planern, Auftragnehmern, Architekten und Betreiberorganisationen organisiert ist. Das heißt, alle, die an der Umsetzung eines Bauprojekts beteiligt sein können. Im Rahmen der Informationsmodellierung werden Informationen über das Bauwerk gesammelt und genutzt, um als Grundlage für Entscheidungen in allen Bauprozessen zu dienen. Was bringt dieses System in der Praxis? Diejenigen, die es eingeführt haben, bestätigen eine Verringerung der Fehler und Änderungen im Projekt aufgrund einer verbesserten Kommunikation zwischen allen Beteiligten des Arbeitsprozesses sowie eine höhere Genauigkeit der Prognosen und Kontrollen. BIM verfügt über eine außergewöhnliche Leistungsfähigkeit – dieses System hebt Architekten auf ein höchstes Niveau der Meisterschaft und ermöglicht ihnen, in Dimensionen zu denken. Die Funktionsweise des Systems lässt sich mit einem Cloud-Speicher oder einem globalen Netzwerk vergleichen, in dem alle Informationen zu Bau, Planung usw. gesammelt werden. Diese werden in Echtzeit erfasst und in die virtuelle Welt hochgeladen. Danach können alle Informationen überall dort eingesehen werden, wo es einen Internetzugang gibt, und es können Korrekturen vorgenommen und Routinevorgänge automatisiert werden, sodass man sich ganz auf die kreative Arbeit konzentrieren kann. Die unglaublichen Möglichkeiten der BIM-Software und ihre ständige Weiterentwicklung ermöglichen es, ein dreidimensionales Modell des Projekts zu bewerten. Dank der Integration aller Bauprozesse in BIM-Modelle kann der Bau unter Berücksichtigung der Architektur der nachhaltigen Entwicklung durchgeführt werden. Es ist möglich, alle Vor- und Nachteile des Projekts vollständig zu untersuchen, alle Schwachstellen zu beheben, rechtzeitig Änderungen vorzunehmen, die Energie- und CO2-Kosten durch den Einsatz spezieller Materialien zu berechnen und zu reduzieren.

Die Montage aus vorgefertigten Elementen und Modulen wird aufgrund ihrer Schnelligkeit und Wirtschaftlichkeit immer beliebter. Die Bausteine und Konstruktionen werden in der Werkstatt vorbereitet und vor Ort einfach zusammengebaut. Dies trägt zur Kostensenkung und Beschleunigung des Bauprozesses bei. Im Holzhausbau werden vorgefertigte Wohnblöcke für Mehrfamilienhäuser aus Cross Laminated Timber (X-LAM)-Platten zusammengesetzt. Diese zeichnen sich durch eine hohe Festigkeit aus und werden daher beim Bau von Mehrfamilienhäusern verwendet. Mit dieser Technologie wurde das höchste moderne Holzhaus gebaut. Derzeit werden Technologien zur Herstellung komplexerer MEP-Elemente (Mechanical, Electrical, and Plumbing – Mechanik, Elektrik und Sanitär) eingeführt.

Internet of Things-Anwendungen (IoT) wurden entwickelt, um die Arbeit von Ingenieuren und

Planern zu erleichtern und zu vereinfachen. Während der Planung eines Objekts kann der Fachmann Informationen über alle neuen Materialien erhalten und diese in den Bau einfließen lassen. Alle erforderlichen Materialien und Komponenten werden direkt auf die Baustelle geliefert.

3D-Druck ist eine Technologie, mit der sich die erforderlichen Bauelemente mit unglaublicher Geschwindigkeit und Präzision herstellen lassen. In BIM-Programmen wird diese Technologie sehr intensiv genutzt und gibt ihre Position nicht auf. Natürlich sind 3D-Drucktechnologien auch auf Baustellen sehr gefragt, mittlerweile werden ganze Häuser gedruckt.

Laser-3D-Scanner und Drohnen. Mit Hilfe von Laser-3D-Scanning wird es möglich sein, das Modell auf der Baustelle zu betrachten und die notwendigen Änderungen vorzunehmen. Außerdem werden Drohnen eingesetzt, die Informationen von den Objekten in Echtzeit sammeln und zur Überprüfung und Verarbeitung an den Computer übertragen. Dies ermöglicht eine genaue Kontrolle des Bauprozesses.

4D-, 5D- und 6D-Scannen. Mit Hilfe des 4D-Scannens lassen sich zeitliche Bauintervalle festlegen. Es kann abgeschätzt werden, wie viel Zeit für die Umsetzung einer der technischen Lösungen aufgewendet werden muss. Die 5- und 6D-Modellierung ermöglicht es, nicht nur das Aussehen, sondern auch die Wärmeisolierung, die Akustik und andere Eigenschaften des Projekts zu bewerten. Bereits in der Modellierungsphase können die Kosten und die Energieeffizienz des Projekts berechnet werden.

Mit einer speziellen Brille kann der Kunde das Präsentationsmodell im Büro betrachten. Die Augmented-Reality-Funktion ermöglicht es dem Kunden und dem Ingenieur, mit einer mit dem Computer verbundenen Brille das Modell in Originalgröße in der Landschaft zu begutachten. So können sie sofort die Notwendigkeit aller im Entwicklungsprozess vorgenommenen Änderungen und deren Wirksamkeit am Objekt beurteilen. Natürlich ist eine solche Entwicklung etwas schockierend und möglicherweise beängstigend. Aber Beispiele für unglaubliche Projekte, die bereits in verschiedenen Städten der Welt gebaut wurden, seien es fliegende Häuser in Japan, die zum Schutz vor Erdbeben geschaffen wurden, oder mit einem 3D-Drucker gedruckte Häuser in China, machen deutlich, dass wir uns in einer neuen Ära der Bautechnologie befinden. Und das kann nur Freude und Inspiration hervorrufen.

Praktisch täglich tauchen auf dem Weltmarkt neue Ideen und Vorschläge auf, wie man maximalen Komfort und Sicherheit in modernen Wohngebäuden gewährleisten kann. Wissenschaftler aus aller Welt arbeiten an der Entwicklung neuer, extrem widerstandsfähiger und sicherer Baumaterialien und entwickeln unglaubliche, manchmal geradezu futuristische architektonische Ideen. Und all dies wird in die Realität umgesetzt. Natürlich können wir uns den innovativen Technologien, die bereits im Bauwesen eingesetzt werden, nicht verschließen.

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ECONOMIC AND CULTURAL IMPACT OF TOURISM

The tourist trade is booming nowadays. Superb system of communication by air, sea and land make it possible for us to travel in different countries at a moderate cost. What was once available only for the very rich, is at present within everybody`s grasp. Today travellers enjoy a level of comfort which the lords and ladies on grant tours in the old days couldn`t have dreamed of. Many trips are being planned by tourist organizations: family trips, package tours, chartered flights, trips for youngsters and many others.

Owing to the facts mentioned above over the decades, tourism has experienced continued growth and deepening diversification to become one of the fastest growing economic sectors in the world. Modern tourism is closely linked to development and encompasses growing number of new destinations. These dynamics have turned tourism into a key driver for socio-economic progress. Tourism has become one of the major players in international commerce, and represents at the same time one of the main income sources for many developing countries. This growth goes hand in hand with an increasing diversification and competition among destinations. But it is not a secret that the

contribution of tourism to economic well-being depends on the quality and the revenues of the tourism offer.

The World Tourism Organization (UNWTO) assists destinations in their sustainable positioning in ever more complex national and international markets. As the UN agency dedicated to tourism, UNWTO points out that particularly developing countries stand to benefit from sustainable tourism and acts to help make this a reality. The World Travel & Tourism Council (WTTC) is the global authority on the economic and social contribution of Travel & Tourism. WTTC promotes sustainable growth for the sector, working with governments and international institutions to create jobs, to drive exports and to generate prosperity. Economic Impact of Tourism According to the World Tourism Organization: 698 million people traveled to a foreign country in 2023, spending more US$ 478 billion. In 2026, this is expected to grow by 5.0%, and the world is expected to attract 1,237,470,000 international tourist arrivals.

It`s quite obvious tourism can induce the local government to make infrastructure improvements such as better water and sewage systems, roads, electricity, telephone and public transport networks. This can improve the quality of life for residents as well as facilitate tourism. What is more, there are also fantastic cultural advantages to tourism. It can be a source of pride for local communities, and allows them to look at their history and cultural heritage and develop their own community identity. This helps the local residents to maintain their traditions and culture, while also showcasing it for all the visitors. This advantage of tourism is what has saved many local heritage sites from destruction, in addition to giving tourists a wonderful insight into the local ways of life. Tourism can help to preserve the history of a region that may be at risk of being lost.

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STATE AND DEVELOPMENT OF THE BRAZILIAN DIGITAL INFORMATION SOCIETY TODAY

In June 2019, Brazil launched the National IoT Plan, which aims to “promote the implementation of IoT as a tool for sustainable development of Brazilian society, which can increase competitiveness, strengthen the national production chain and promote a higher quality of life” (dated 25 June 2019). The plan identifies 75 initiatives organized along four key thematic axes. Agribusiness and manufacturing are among the priority sectors of the plan.

Brazil has made significant progress in promoting access to education in recent decades. However, despite increased spending on education and widespread access to free primary and secondary education, education levels remain low. More than 50% of Brazilians have not completed secondary education, and 17% have not completed primary education, well above the OECD average of 2%. Enrolment in vocational and technical courses is low, with only 5% of secondary school students choosing technical courses. The poor results of the OECD’s Programme for International Student Assessment (PISA) study indicate that the quality of education is poor and that outcomes vary widely depending on the socio-economic background of the students.

Digital technologies can also improve businesses’ access to skills and talent through better job placement sites and the outsourcing of key business functions, all of which can help improve performance. New technologies can also facilitate access to a variety of financial instruments. Digital technologies have the potential to increase productivity in businesses across all economic sectors. Big data and data analytics can help businesses better understand their production processes, the needs of their customers and partners, and the general business environment. Finally, online platforms can support the productivity of service businesses that lack technology knowledge by providing booking options and efficient matching algorithms based on consumer ratings and review systems.

The Internet of Things, in particular, holds significant potential for process innovation and efficiency gains. Modern sensors allow the collection of vast amounts of data that can be processed by intelligent devices and integrated into production decisions. The resulting large data sets can generate additional benefits, such as the integration of new services and service providers into the value chain.

Despite widespread Internet access, Brazilian businesses lag behind OECD countries in the use of the Internet and digital technologies, largely due to low adoption rates among SMEs. Advanced manufacturing, which combines digital technologies, robotics, IoT and data analytics to improve production processes and product quality, is still in its infancy.

Low skills levels prevent Internet users and workers from effectively using and benefiting from digital technologies, creating a second-level digital divide. Skills shortages are also a major cause of low productivity in Brazil. Brazilian employers report difficulties hiring technicians, skilled workers and engineers. ICT professionals represent the second-largest shortage.

Brazil has launched an online training program, Brazil Mais Digital, aimed at young people aged 16 to 25 to strengthen their IT skills. New opportunities for vocational training have also been created as part of the Pronatec program. While progress has been made, the high dropout rate suggests that these programs could be improved to better meet educational and skills needs. There is also room for better tailoring university curricula to the professional profiles demanded by the labor market.

Digital technologies and big data can not only create demand for new skills, but can also help increase the effectiveness of education and training programs. Analyzing online job postings can provide up-to-date information on skills needs in small areas. Big data can be used to track and evaluate the labor market outcomes of vocational education and training participants, providing information on how vocational education and training can be improved. The process of collecting and disseminate up-to-date online information on the performance of universities helps potential students make informed decisions.

Hermela Samuel
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DIGITAL FOUNDATIONS FOR ECONOMIC ETHIOPIAN GROWTH

Everybody knows that digital literacy is no longer a luxury today – it is a necessity for inclusive development.

Until 2021, Ethiopia's telecom sector was served by a single state-owned provider, resulting in a monopoly environment. Ethiopia lagged other countries in eastern and southern Africa, with high costs and limited access for voice and data services, and no mobile money services. The conflict in the north of the country, between 2020 and 2022 caused an estimated $600 million in damage to communications infrastructure. The lack of competition and choice in service availability hindered economic growth, leaving millions without access to essential digital services or opportunities for economic inclusion.

The World Bank's engagement around digital access, services, and inclusion in Ethiopia spans multiple projects, including the Digital Ethiopia Foundations Project, the Ethiopia Digital ID for Inclusion and Services Project (to expand digital identification to enable inclusive service delivery), and the Eastern Africa Regional Digital Integration Project (to advance digital market integration in East Africa). With over $630 million in International Development Association (IDA) support across the three projects, the Government of Ethiopia adopted a comprehensive approach to addressing the country's digital challenges, focusing on fostering competition in the telecom market, improving connectivity, launching Digital ID and enabling digital service delivery. To liberalize the telecom sector, IDA supported policy and regulatory reforms, enabling market entry for private operators like Safaricom. These efforts increased competition, reduced prices, and enhanced internet quality. The private sector has committed more than $1 billion in license fees and a further $3 billion in investment in digital infrastructure, including in the expansion of mobile broadband, bridging connectivity gaps in underserved areas, particularly rural communities, and launching mobile money services.

Through IDA we leveraged our convening power to bring together stakeholders, facilitating collaboration between government entities and private sector players toward market liberalization. Capacity-building initiatives strengthened the regulatory environment and enhanced the technical expertise of Ethiopian institutions. Furthermore, innovative financial models, such as Public-Private Partnerships, mobilized an estimated $8 billion in private sector investment to accelerate digital transformation. Promoting women's participation in the digital economy through digital ID and digital skills training programs was critical. This holistic strategy fostered entrepreneurship by creating an

enabling environment for digital firms which has helped create jobs. These interventions are helping to expand access to digital services and catalyze economic growth.

The project interventions have contributed to liberalizing the telecom market and supporting the Ethiopian Communications Authority (ECA) to facilitate new market entry; investing in digital public infrastructure to enhance service delivery; promoting digital entrepreneurship, creating a vibrant ecosystem of newly licensed firms; and supporting policy reforms, including the passage of the Digital ID Proclamation and Data Protection Proclamation. This multi-faceted approach fostered innovation and economic growth, with significant benefits for underserved populations.

Through our nationwide International Certification of Digital Literacy training initiative, we have equipped over 12,000 academic staff and nearly 200,000 students with essential digital skills, while also reaching close to 3,000 community members through university engagement programs. With 64 certified trainers deployed across 50 public universities and TVET institutions, and with localized content in Amharic and Afaan Oromo underway, we are building a digitally empowered generation aligned with Ethiopia's ICT in Education Policy and national development goals." Zelalem Assefa, PhD, Chief Executive Officer (CEO), ICT and Digital Education, FDRE, Ministry of Education.

William Antonio
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DIGITAL TRANSFORMATION OF ANGOLA'S ECONOMY

In the 20th century, Angola was considered a third-world country. In the 21st century, Angola, like many countries on the African continent, embarked on a path to digital development.

At a ceremony in Luanda marking the laying of the first stone for a national cloud platform the country's Minister of Telecommunications, Information Technologies and Social Communication, Mário Oliveira, underscored that this project will accelerate both public-sector digitalisation and broader economic modernisation. Since "digital transformation" frames the entire initiative, it anchors the reader from the outset with clarity.

This national cloud platform represents a building block in the government's larger digital blueprint. It signals a shift from pilot schemes to scalable infrastructure. Moreover, Oliveira highlighted a parallel initiative in skills development: in partnership with Huawei, the government has trained 5,000 ICT technicians and aims to equip 10,000 by 2027. Transition words such as "moreover" and "furthermore" help maintain fluid narrative flow. Equally notable are projects like AngoSat-II and a forthcoming Earth-observation satellite. These efforts extend the digital transformation agenda into remote sensing and policy planning. They promise to enhance oversight in agriculture, resource management and national security – each reinforcing systemic resilience.

Oliveira also drew attention to growing emphasis on areas such as cyber-security, artificial intelligence, and digital signatures. These technologies underpin a robust digital ecosystem designed to attract foreign investment while protecting local stakeholders. By integrating cybersecurity and digital credentialing, the government seeks to reduce risk and raise confidence among both public agencies and private investors. These efforts align neatly with the broader goal of digital transformation. They serve both to modernise public administration and to underpin digital public-services infrastructure. The balanced strategy blends physical infrastructure, human capital and regulatory frameworks, forming a multi-layered approach to technological change.

Rapid rollout of infrastructure must be matched with inclusive access and regulatory clarity. Angola's success will depend on not only constructing digital systems but ensuring they yield tangible benefits for citizens and attract quality investment.

In summary, Angola's commitment to its digital agenda is progressing steadily. The fusion of infrastructure, capacity building and regulatory foresight outlines a credible path toward digital transformation. It positions the nation to leverage technology for both economic diversification and improved governance.

SECTION 1.
TRANSPORT TECHNOLOGIES AND EQUIPMENT

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MODERN CHALLENGES OF THE MILITARY LOGISTICS FORCES

In the context of military conflict, particular attention must be paid to transforming Ukrainian military logistics system in order to ensure the rapid supply of necessary resources to the armed forces, the fulfillment of military tasks and the preservation of the country's economic security. The Logistics Forces of the armed Forces of Ukraine play crucial part in the supply process providing the combat zones with all necessary weapons, equipment, vehicles and spare parts etc.

The Logistics Forces of the Armed Forces of Ukraine are a structure within the Armed Forces of Ukraine that ensures the front's uninterrupted functioning by organizing supplies and maintenance. The Logistics Forces Command was established on May 29, 2018 to consolidate the services of the Rear and Armaments, which were previously had been operating separately. This transformation aimed to enhance the efficiency of the Armed Forces logistics processes. «The main function of the Logistics Forces is technical and logistical support of the Ukrainian Armed Forces including storage, repair, and transportation of weapons, ammunition, equipment, food and fuel. Their structure contains central management, subordinate units around Ukraine: arsenals, storage and repair bases, warehouses, automobile battalions,etc.» [1].

But the urgent problems and challenges logistics faces include: destruction of roads, bridges, railway; insufficient number of modern logistics terminals and warehouses;lengthy customs checks and bureaucracy;limited investment in recovery and modernization; high logistics costs due to long routes and multiple re-loadings; low levels of digitalization (cargo tracking, e-documents); lack of an integrated national logistics management platform; security risks from active hostilities, including drone attacks on supply routes. It is not the full list of the problems and obstacles.

Moreover, since the beginning of the war, logistics real estate has suffered significant damage, with some warehouses being completely destroyed. The fact that warehouses are strategically important objects led to such devastating destruction, as the enemy strikes them purposefully or uses them as locations for their occupation bases. Russian troops destroyed more than 440,000 sq. m (20%) of logistics real estate in the capital region. During 2 months of the war in Ukraine, warehouse and logistics buildings worth USD 1 billion were destroyed [2].

In the conclusion, delivering aid, especially to high-risk areas, requires approvals from military, civil, and security authorities. To avoid delays and protect operations, communication channels and clear stage-by-stage planning needs to be established.

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ANALYSIS OF METHODS FOR SURVEYING PASSENGER FLOWS ON URBAN BUS ROUTES

Passenger flow surveys are conducted to determine passenger transportation needs and their

distribution in time and space. There are various methods of passenger flow surveys, but experimental methods based on research conducted according to developed programs, methodologies, and rules have become the most widespread for organizing urban transportation. The most well-known methods of passenger flow surveys are as follows:

- ticket-based;
- questionnaire-based;
- survey-based;
- tabular;
- visual estimation;
- silhouette.

If surveys are conducted using ticket, questionnaire, or survey methods that take into account the directions of passenger travel on the route, the processing of these materials can result in a matrix of inter-stop passenger correspondence. The data contained in this matrix is the most complete and universal. With the help of this data, it is possible to obtain information about the distribution of passenger flows along the route, passenger flow capacity, passenger exchange at each stop, the total volume of passenger traffic on the route, etc.

If the surveys are conducted using the tabular method, then as a result of processing these materials, it is possible to determine all of the above technical and operational indicators of the passenger transport process, except for the matrix of inter-stop passenger correspondence.

The visual method is used by the bus driver. When on the busiest sections of the route, the driver visually estimates the number of passengers on the bus.

The silhouette method is used when surveying the number of passengers on buses at stops along the route. Accountants (who have undergone prior training) visually estimate the number of passengers on the bus based on template silhouettes.

The above experimental survey methods involve a large number of accountants, require considerable time to collect and process data, and are very labor-intensive. Therefore, in modern conditions, automated methods should be used in transport, in which information about passenger flows is collected using special contact, photoelectric, tensometric, and other devices installed in rolling stock. The automated survey methods used can be similar to the tabular method in terms of the range of results obtained. At the same time, as some studies show, the cost of obtaining and processing passenger flow survey materials is reduced by 15-20 times compared to manual methods.

Thus, based on passenger flow survey data, one of the main indicators of the transportation process is established – transportation volumes and their distribution in time and space.

In addition, if the distances between stops are known, this data can also be used to determine: passenger turnover; average passenger travel distance; shift coefficient; bus capacity utilization coefficients.

The survey results also determine the useful (productive) transport work of the rolling stock on the route.

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BLOCKCHAIN IN LOGISTICS: ENHANCING TRANSPARENCY AND EFFICIENCY AMID CHALLENGES

Blockchain is steadily revolutionizing the logistics sector by enhancing transparency, accuracy, and security in supply chain management. By enabling the creation of a shared, tamper-proof digital ledger of transactions, this technology facilitates fair and trustworthy interactions among all participants in logistics processes. Market projections indicate that the value of blockchain solutions in transport and logistics will grow by $2.23 billion by 2027, with an average annual growth rate of 39.78%, reflecting a

rising demand for blockchain in supply chain management. This overview explores the fundamentals of blockchain technology, its pivotal role in logistics, its benefits for the industry, and the challenges companies face during implementation.

Blockchain functions as a distributed digital ledger where transaction data is stored in interconnected blocks forming a sequential chain. This data is replicated across numerous network nodes, making it virtually impossible to alter or falsify records. Such a design promotes transparency and builds trust within logistics operations. Transactions are validated by miners who solve complex mathematical problems to add new blocks, ensuring the integrity of the ledger. Additionally, blockchain supports smart contracts – self-executing agreements triggered when predefined conditions are met. This enables real-time tracking of shipments, reduces errors, speeds up processes and improves service quality.

Implementing blockchain in logistics significantly boosts efficiency and trust among stakeholders. The system maintains an immutable, detailed chronological record of each product's journey from supplier to end user. This immutability enhances oversight and accountability, allowing logistics companies to swiftly track shipments and elevate transparency, which in turn improves planning and mitigates risks.

By eliminating paper-based bureaucracy and automating transactions through smart contracts, logistics operations become faster and more efficient. This reduces human errors, expedites document processing, and lowers administrative costs, providing businesses with consistently accurate data and decreased operational expenses throughout the supply chain.

Because blockchain prevents alterations to recorded data, it serves as a robust defense against fraud. Its resistance to external tampering ensures secure storage of critical business information and intellectual property, thereby increasing industry trust.

Integrating blockchain with customs authorities enables real-time data exchange about cargo, speeding up customs clearance, reducing queues, and optimizing international trade. This results in more organized and controlled import-export processes.

Despite these advantages, blockchain adoption faces notable challenges. Large logistics networks generate vast amounts of real-time data, which can strain blockchain performance as transaction volumes increase, potentially causing delays and reducing operational efficiency. Many logistics companies rely on outdated systems that are difficult to integrate with blockchain technology, requiring substantial technical effort and resources, which may slow adoption.

Blockchain presents promising opportunities for the logistics industry by enabling secure, transparent, and automated supply chains. However, realizing its full potential demands overcoming challenges related to scalability, legal frameworks, and integration with existing systems. Over time, blockchain is poised to become an essential tool for enhancing the efficiency of global logistics.

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KEY TECHNOLOGICAL FEATURES OF MODERN WAREHOUSES

A modern warehouse is a complex facility, both from a technical and managerial point of view. Warehouses are needed at all stages of material flow, from the source of raw materials to the final consumer of finished goods. This circumstance explains the wide variety of warehouses for different purposes.

To make the best choice of warehouse, you need to have an idea of their main types and purposes. Modern warehouses are classified according to the following criteria: in relation to logistics areas – production and distribution; in relation to participants in the logistics system – warehouses of manufacturers, trading, transport, forwarding, and logistics companies; by form of ownership – owned and leased; by functional purpose – long-term storage, transhipment, distribution, special; by product range specialization – specialized, universal, mixed; by storage mode – unheated, heated, cold storage, warehouses with a fixed climate mode; by technical equipment – non-mechanized, mechanized,

automatic; by type of warehouse buildings and structures – open, platforms, closed; by scale of activity – central, regional, local. Today, the most widely used classification system for warehouse premises divides them into four classes: Class A, Class B, Class C, and Class D.

Class A: modern warehouse building; single-story (single-volume) building constructed using modern technologies and high-quality materials; high ceilings of at least 8 m; fully adjustable temperature control; thermal curtains on the gates; automatic dock-type gates with a height-adjustable hydraulic ramp; security alarm system and video surveillance system; office space within the warehouse; (Fig. 1).

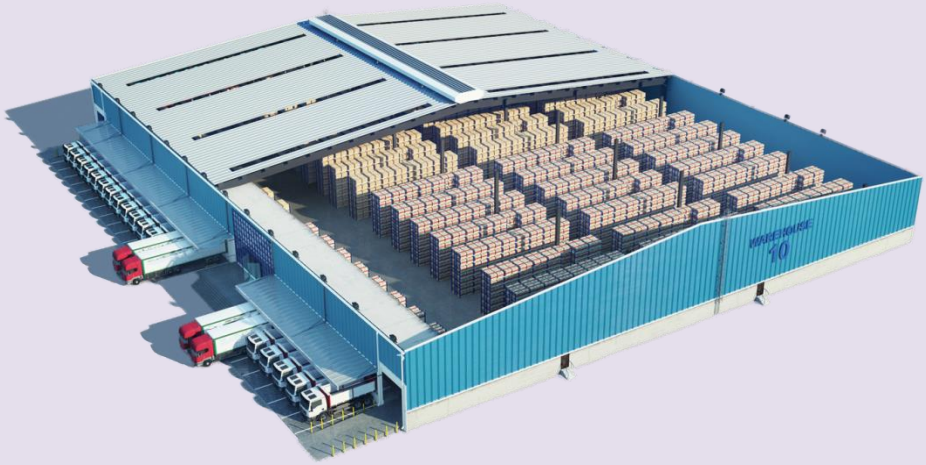

Fig. 1 – Exterior view of a typical Class A warehouse

Class B: a capital, usually multi-story building; ceiling height from 4.5 to 8 m; floor – asphalt or concrete without coating; temperature range from +10 to +18 °C; fire alarm and hydrant fire extinguishing system; ramp for unloading vehicles; office space adjacent to the warehouse; perimeter security;

Class C: permanent production facility or insulated hangar; ceiling height from 3.5 to 18 m; heated premises (temperature in winter +8...14 °C); floor – asphalt, concrete tiles or uncoated concrete; gates at ground level, vehicles can enter the premises;

Class D: basement premises or civil defence facilities, unheated production premises or hangars.

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TECHNOLOGICAL EFFECT OF IMPLEMENTING COMBINED TRAFFIC MODES ON URBAN BUS ROUTES

In the context of the transition to a market economy, transport companies need to determine the number of vehicles and the forms of organization of the transport process on the route that would lead to maximum productivity of the rolling stock and at the same time take into account the need to transport passengers with a specified quality. Quite often, in urban transport conditions, different modes of transport, known as combined modes, are used on the same route.

For example, regular service on a route can be combined with high-speed, express, or shortened service. On some routes, depending on their specific conditions, through the rational organization of different modes of transport, it is possible to reduce unproductive

transport work, reduce the number of vehicles serving the route, and therefore reduce the cost of transportation. As an example of the effective use of combined traffic modes, let us consider the passenger flow distribution diagram on a nominal route (Fig. 1).

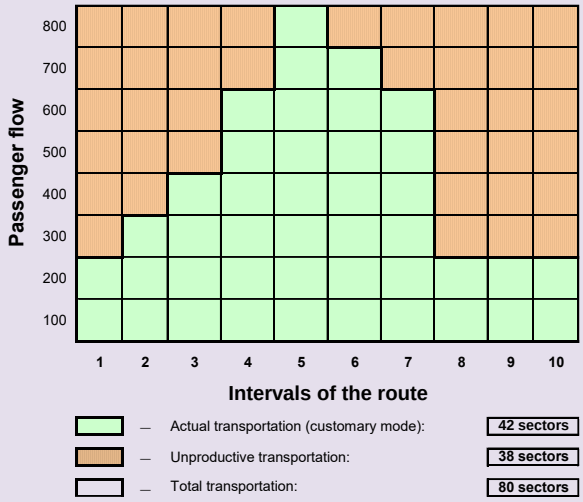

Fig. 1. Passenger flow diagram for a nominal route with normal traffic conditions

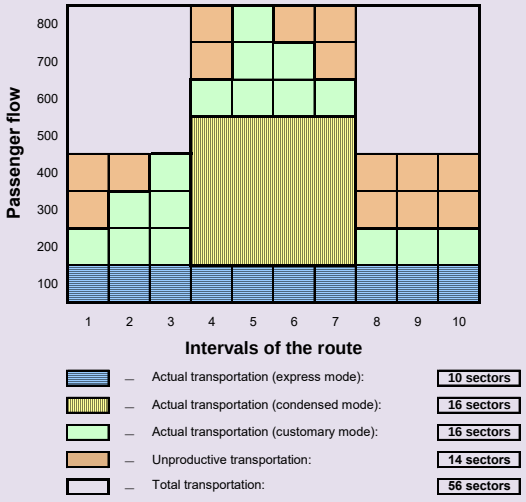

Fig. 2. Passenger flow diagram for a route with a combined traffic mode

Analysis of passenger flow patterns (Fig. 1) suggests that there are significant correspondences between the end points and in the middle of the route. Therefore, it (the diagram) can be smoothed out (approximated) by various forms of connection: the usual form is supplemented by reduced and express connections, which will reduce the amount of unproductive transport work. Fig. 2 shows an example illustrating the fundamental possibility of reducing unproductive transport work (W_N) by introducing express and shortened connections on routes No. 4, No. 5, No. 6, and No. 5. This measure will reduce W_N from 38 to 14 "arbitrary units."

It should be noted that the introduction of high-speed, express, or shortened connections does not affect either the route taken by passengers or the number of their trips, and therefore does not change either the average distance travelled or the volume of passengers transported. However, this does change such indicators of the transport process as the total mileage of rolling stock, its occupancy rate, the number and productivity of vehicles, operating costs, the cost of transportation, and the total time spent by passengers on travel, including time spent on connections and waiting.

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A SYSTEMIC APPROACH TO REPLACING ROLLING STOCK IN URBAN PASSENGER TRANSPORT TO ENSURE THE SUSTAINABLE DEVELOPMENT OF THE URBAN TRANSPORT SYSTEM

Modern cities are constantly growing, and with this growth comes an increased burden on the urban transport system. Passenger transport plays a key role in ensuring the mobility of the population, but outdated public transport rolling stock often does not meet modern requirements. This leads to a decline in service quality, increased travel times, environmental degradation and reduced passenger comfort. Therefore, a systematic approach to rolling stock replacement is extremely important for the development of urban transport and improving the quality of life of residents.

A systematic approach means considering the process of rolling stock renewal as a holistic system, taking into account not only the technical characteristics of new vehicles, but also economic, environmental and social aspects. This allows for a comprehensive solution to transport-related problems and creates conditions for sustainable urban development.

One of the key elements of this approach is the selection of modern rolling stock that meets international standards of environmental friendliness and energy efficiency. New vehicles have a significantly lower impact on the environment, which is especially important for large cities with high levels of air pollution. In addition, modern transport provides a higher level of comfort and safety for passengers, which contributes to an increase in demand for public transport and a reduction in the use of

private cars.

An important part of a systematic approach is careful planning of the rolling stock renewal process. This includes developing long-term strategies that take into account demographic trends, urban infrastructure development, and financial capabilities. Planning helps avoid chaotic purchases and ensures gradual renewal that does not disrupt the stability of the transport system.

Equally important is the development of infrastructure that supports the operation of new transport. This includes the modernisation of depots, the creation of charging stations for electric transport, and the introduction of modern management and monitoring systems. Such infrastructure ensures the efficient operation of transport and allows for a rapid response to changes in operating conditions.

The social aspect of the systematic approach is to improve the skills of the staff who maintain the new rolling stock and to involve the public in the renewal process. Open communication and taking residents' opinions into account help build trust and support for reforms in the transport sector.

A systematic approach to replacing rolling stock in urban passenger transport is a prerequisite for creating an efficient, environmentally friendly and comfortable transport system. It allows all aspects that affect the quality of transport and the sustainable development of the city to be taken into account, ensuring a comprehensive and coordinated solution to problems.

The application of such an approach contributes to reducing air pollution, increasing energy efficiency, improving passenger comfort and safety, and stimulates the transition to more sustainable forms of mobility. At the same time, it requires careful planning, infrastructure development, staff training and active public participation.

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OPTIMIZING DELIVERY ROUTES IN AUTOMOTIVE LOGISTICS USING MODERN DIGITAL TOOLS

The efficient delivery of auto parts and vehicles is a critical challenge for the modern automotive industry. With complex supply chains spanning the globe, companies constantly face the task of minimizing delivery times and costs while maximizing reliability. Traditional planning methods often rely on static maps and fixed schedules, which struggle to account for dynamic real-world conditions like traffic jams, road closures, or sudden changes in demand. This creates a need for more intelligent and adaptive routing systems that can process real-time information.

Intelligent routing systems use a combination of GPS data, real-time traffic updates, and historical patterns to dynamically calculate the most efficient path for a delivery vehicle. This approach moves beyond simply finding the shortest distance to finding the fastest and most cost-effective route, considering factors such as fuel consumption, toll roads, and driver working hours. By integrating with a Transportation Management System (TMS), these tools provide logistics managers with a powerful platform for oversight and decision-making, leading to a significant reduction in operational costs and improved customer satisfaction through more accurate delivery estimates [1].

The core of these modern systems often involves machine learning algorithms. Unlike rigid rule-based programs, these algorithms can learn from vast amounts of historical delivery data. They can identify patterns that are invisible to the human eye, such as how weather conditions on a specific highway corridor typically impact travel time or which delivery windows in a particular district are most prone to delays. This ability to learn from experience allows the system to make increasingly accurate predictions and continuously refine its routing recommendations [2]. For instance, a model can be trained to prioritize routes that have a 95% or higher historical on-time delivery rate.

The practical benefits of implementing such a digital solution are substantial. Case studies from leading logistics providers show that dynamic routing can lead to a reduction in total distance driven by up to 10-15%, directly lowering fuel costs and the company's carbon footprint. Furthermore, the decrease in unnecessary idling in traffic and optimized driving schedules contribute to reduced vehicle wear and

tear. The enhanced visibility provided by live tracking also allows companies to proactively inform customers about the status of their deliveries, strengthening brand trust and service quality [3].

In conclusion, the adoption of intelligent routing systems is no longer a luxury but a necessity for competitive automotive logistics. By leveraging real-time data and machine learning, companies can transform their supply chains into agile, efficient, and customer-centric operations. The transition to such digital tools represents a crucial step towards building a more resilient and sustainable logistics framework for the future of the automotive industry.

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RAILWAY TRACK FACILITIES IN UKRAINE AND WITHIN THE MILITARY STRUCTURE OF THE STATE SPECIAL TRANSPORT SERVICE

Railway track facilities, also known as track maintenance infrastructure or permanent way, represent one of the core sectors of railway transport. This field includes the railway track with all its constructions, engineering elements, technical buildings, and maintenance enterprises that ensure the proper functioning, inspection, and repair of the track. The railway track structure comprises the upper track structure (rails, fastenings, sleepers, and ballast), subgrade, artificial structures (bridges, tunnels), drainage and water removal systems, level crossings, and other engineering elements necessary for the safe and continuous movement of trains.

Functions and Technical Aspects

The main functions of railway track facilities include the planning and construction of track structures, technical and routine maintenance, reconstruction, and capital repair of railway lines. Additionally, it involves the organization of diagnostic and geotechnical control works that monitor the state of the track and ensure traffic safety. Both traditional manual methods and modern mechanized tools—such as track-laying cranes, ballast regulators, tamping machines, and ultrasonic defect detectors—are used to maintain and modernize track infrastructure.In Ukraine, the design, construction, and operation of railway tracks are regulated by national technical norms and standards established by the Ministry of Infrastructure. Technical documentation defines construction technologies, repair criteria, and safety regulations, based on the standard gauge width of 1435 mm used on Ukrainian railways.

Historical and Organizational Context

The system of railway track facilities in Ukraine was formed over many decades as part of the state railways and military transport units. After the dissolution of the Soviet Union, Ukraine adapted its railway maintenance structures and technical regulations to modern national and European standards. Specialized educational programs and scientific research institutions were established to train engineers and improve the efficiency of track maintenance systems.

The Role of the State Special Transport Service (SSTS)

The State Special Transport Service of Ukraine is a specialized military formation that originated from railway troops. It is responsible for carrying out transport and recovery operations both in peacetime and wartime. The SSTS plays a crucial role in ensuring the functioning and restoration of railway and road transport infrastructure, including bridges, tunnels, and other engineering constructions damaged during military operations or emergencies. In 2025, the Verkhovna Rada of Ukraine officially recognized the SSTS as a military formation within the national security and defense sector (law adopted

on October 9, 2025). This decision strengthened its authority in performing strategic logistics and reconstruction missions, especially in the context of ongoing military challenges and the need to protect critical infrastructure.

Main Tasks of the SSTS in the Field of Track Maintenance:

Rapid restoration and repair of damaged railway lines, bridges, and crossings using mobile technical units and specialized machinery.

Support of military and humanitarian logistics, ensuring uninterrupted transport of military supplies, evacuation of civilians, and delivery of critical cargo.

Training and cooperation, including preparation of engineering brigades and collaboration with universities that train specialists in track engineering, transport infrastructure, and machinery operation.

Education and Human Resources

Training of railway engineers and maintenance specialists is carried out at leading Ukrainian technical universities, particularly those specializing in railway transport and infrastructure.

The SSTS also conducts internal training and retraining programs for officers and civilian experts. Educational materials, such as A. M. Shtompel's Lecture Notes on Railway Track Facilities, provide practical knowledge about track structures, materials, and modern mechanization systems.

Modern Challenges and Prospects

The main challenges faced by Ukraine's railway track facilities include the high wear of infrastructure assets, the need for modernization, implementation of advanced diagnostic technologies, and maintaining logistics during wartime conditions. The shortage of qualified personnel and the need for mobile, fast restoration methods are also key concerns.Future prospects include integration of European railway standards, digitalization of track diagnostics, and enhanced coordination between civilian railway services and the SSTS in protecting and restoring critical transport infrastructure.

Conclusion

Railway track facilities are a critical component of Ukraine's transport system. In the current security environment, their importance has significantly increased due to the role of the SSTS, which ensures the resilience, restoration, and protection of railway infrastructure during both peacetime and wartime. The combination of technical expertise, educational development, and operational readiness defines Ukraine's capacity to maintain sustainable and secure transport operations under any conditions.

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INTEGRATED STRATEGIES FOR IMPROVING THE EFFICIENCY OF BUS TRANSPORT IN URBAN TRANSPORT SYSTEMS

Bus transport remains one of the most common and important types of public transport in urban agglomerations. It provides access to different areas of the city, promotes population mobility and reduces the load on the road network. However, modern challenges such as population growth, increased traffic flows, environmental requirements and higher passenger expectations require a comprehensive review of existing approaches to the organisation of bus transport. Improving its efficiency is a key task for the development of urban transport and improving the quality of life of residents.

1. Renewal of rolling stock. One of the fundamental steps towards improving efficiency is the modernisation of the bus fleet. Modern buses are more energy efficient, produce fewer harmful emissions, and offer improved safety and comfort for passengers. The introduction of electric buses, hybrids and other environmentally friendly vehicles helps to reduce the negative impact on the environment and meets international standards for sustainable development.

2. Optimisation of the route network and timetables. Rational route planning, taking into account passenger flows, transport infrastructure and time of day, reduces delays, avoids congestion and increases the capacity of the system. It is also important to introduce flexible timetables that adapt to changes in demand at different times of the day and days of the week. The use of modern information technologies, such as GPS monitoring, traffic management systems and data analytics, allows for real-time monitoring of bus traffic, forecasting of traffic jams and rapid response to unforeseen situations.

3. Improving the quality of passenger service. Passenger comfort and safety are important factors influencing the choice of public transport. Ensuring comfortable conditions in the passenger compartments, accessibility for people with reduced mobility, the introduction of electronic payment systems and the provision of up-to-date information on transport movements increase passenger satisfaction.

4. Development of transport infrastructure. The efficiency of bus transport largely depends on the availability of appropriate infrastructure. The creation of dedicated bus lanes, the construction of modern bus stops with comfortable waiting conditions, and the development of depots and service centres contribute to increasing the speed and reliability of transport.

5. Introduction of innovative technologies. Modern technologies open up new opportunities for improving the efficiency of bus transport. This includes the automation of traffic management, the use of artificial intelligence to analyse passenger flows, and the introduction of route forecasting and optimisation systems.

6. Social aspect and public involvement. Improving efficiency is impossible without taking into account the needs and expectations of passengers. Active public participation in planning and evaluating service quality helps to build trust and support for reforms.

Thus, improving the efficiency of bus transport is a multifaceted task that requires a comprehensive and systematic approach. Renewing the rolling stock, optimising routes, improving service quality, developing infrastructure, introducing innovative technologies and actively involving the public create conditions for the sustainable development of urban transport.

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THE MAIN PROBLEMS OF RAIL TRANSPORT IN THE USA

Railway transport in the USA plays a crucial role in the economic life of the country. It is a well-known fact that the total length of railway tracks in the USA is the largest in the world. However, railway transport in the USA has its own certain problems, which we will consider in these theses.

The biggest problem facing US railroads is a lack of significant investment, which is leading to train derailments, customer service issues, and problems getting cargo to seaports [1]. An additional problem is the lack of equipment for transportation (for example, containers or special chassis for piggyback transportation) [1]. There is also a problem of organizational interaction between railways and their customers [1].

Currently the railway infrastructure in the USA is aging quite actively. This leads to significant operating costs. Such costs are due to the fact that quite often the railway infrastructure has not been modernized, and accordingly, it currently does not meet modern safety standards. Accordingly, outdated infrastructure requires increased maintenance costs and also limits train speeds [2].

Also, the busiest routes on the US rail network face the problem of limited capacity. This requires the expansion of existing infrastructure and its modernization (for example, increased automation). In turn, the integration of new technologies on the railway requires their compatibility with existing technical means [2].

Additionally, there is a need for labor. This requires an increase in wages on the railways, as well as the development of training for new employees in the railway sector, and the provision of health care programs [2].

It is obvious that solving these problems requires significant investments and state support.

At the same time, it is worth noting that US railways ended 2024 with good profit figures. Also, railway companies are increasing their own investments in the modernization and development of railway infrastructure [3]. At the same time, a very important issue is state support and cooperation between the US government and railway companies. The current US government is demonstrating its readiness to provide quite serious support to railway companies in the US [4].

Considering all of the above, we can conclude that despite numerous and quite serious problems, railway companies in the US will continue their own development and modernization in order to ensure competition with other modes of transport.

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GŁÓWNE PROBLEMY POLSKIEJ INFRASTRUKTURY KOLEJOWEJ

Koleje odgrywają ważną rolę w życiu i gospodarce Polski. Jednak koleje w Polsce mają swoje własne problemy, z których najważniejsze przedstawimy w niniejszej pracę.

W 1990 roku polska sieć kolejowa liczyła 24,1 tys. kilometrów torów [1]. Jednocześnie w 2024 roku polska sieć kolejowa liczyła 19,6 tys. kilometrów torów [2]. Polska dąży do osiągnięcia możliwości poruszania się pociągów na liniach głównych z prędkością 160 kilometrów na godzinę, jednak nie cała infrastruktura torowa jest przygotowana na taką prędkość [2]. Naprzyklad w 2011 roku tylko 8% całkowitej długości torów nadawało się do przewozu pociągów poruszających się z prędkością 160 kilometrów na godzinę [1], a obecnie problem prędkości pociągów w Polsce jest wciąż aktualny [2]. Jednocześnie największa długość torów kolejowych w Polsce (ok. 45,9 proc.) zapewnia ruch pociągów z prędkością 120 – 160 kilometrów na godzinę [2] i ta ilość i prędkość zrosta.

Warto zwrócić uwagę także na transport intermodalny kolejowy. Do głównych problemów

związanych z możliwością realizacji przewozów intermodalnych koleją w Polsce zaliczą się: bardzo małą liczbę terminali, brak równowagi między ruchem pasażerskim i towarowym, co wpływa na rozkład jazdy pociągów intermodalnych (np. w przypadku opóźnień w ruchu jako pierwsze ruszają pociągi pasażerskie), a także znaczne koszty energii elektrycznej potrzebnej do poruszania się pociągów intermodalnych [3].

Oczywiste jest, że rozwiązanie wszystkich powyższych problemów wymaga znacznych nakładów finansowych. Dlatego kwestia pozyskiwania inwestycji finansowych w infrastrukturę kolejową jest dla Polski istotna. Jednocześnie istotne są inwestycje zarówno krajowe, jak i zagraniczne (np. z Unii Europejskiej).

W 2025 roku PKP Polskie Linie Kolejowe ogłosiły, że planowana kwota przychodów, które zostaną przeznaczone m.in. na modernizację infrastruktury kolejowej, wyniesie 25 mld zł [4]. Polska systematycznie stara się finansować rozwój własnej infrastruktury kolejowej i zwiększać jej atrakcyjność dla przewoźników.

Powyższe wskazuje, że pomimo problemów, polskie koleje kontynuują własny rozwój i modernizację.

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COMPREHENSIVE APPROACHES TO TRANSPORT ORGANIZATION FOR ENHANCING LOGISTICS EFFICIENCY AND COMPETITIVENESS

In the current market conditions, companies face numerous challenges related to the organisation of transport. The choice of transport mode, vehicle type, and transport methods and technologies is critical to ensuring the efficiency of logistics processes. Since transport costs account for at least half of total logistics costs, competent management of these aspects directly affects a company's financial results, competitiveness, and market position.

Despite its prevalence, road freight transport remains a complex and multi-component process. It requires not only careful planning, but also smooth coordination between all participants in the supply chain, as well as a high level of responsibility on the part of the carrier. Choosing a reliable transport company with modern technologies, experience, and resources is the key to cargo safety and stable business development.

To achieve maximum efficiency and minimise transportation costs, a number of key aspects should be taken into account:

1. Careful route planning. Determining the optimal route, taking into account the characteristics of the cargo, road conditions, vehicles and regulatory requirements, is the basis for successful delivery.

2. Ensuring cargo safety. Compliance of vehicles and packaging with international and national standards guarantees the safety of cargo and minimises the risk of damage during transport.

3. Reducing delivery times. Optimising logistics processes, including automating order processing and using integrated information systems, reduces transport times and improves customer service efficiency. This contributes to faster turnover of goods and increased sales volumes.

4. Compliance with customs procedures and regulatory requirements. In international transport, it

is important to complete all necessary documents in a timely manner and comply with local rules and standards to ensure the smooth movement of goods across borders.

5. Effective interaction between supply chain participants. The constant exchange of information between the shipper, carrier and recipient allows for a quick response to changes, optimisation of logistics processes, reduction of costs and improvement of service quality.

6. Speed of loading and unloading. This factor is critical for increasing productivity and reducing operating costs. Fast cargo handling allows.

7. Use of innovative technologies. The introduction of digital platforms for logistics management, process automation, and the use of artificial intelligence to forecast demand and optimise routes can significantly increase transport efficiency and reduce costs.

8. Focus on customer needs. Modern consumers value minimal delivery times, complete cargo safety, convenience of receiving and transferring goods, as well as transparency of information about tariffs, transportation conditions and cargo location in real time.

Thus, a comprehensive approach to the organisation of transport, including careful planning, safety, optimisation of delivery times, compliance with customs procedures, fast loading and unloading, as well as the introduction of innovative technologies and customer focus, is the key to successful business development.

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ENHANCING EFFICIENCY IN INTERNATIONAL TRANSPORTATION OF DELICATE FLORAL PRODUCTS: A COMPREHENSIVE LOGISTICS APPROACH

Floral products are one of the most delicate types of goods, requiring special transportation conditions, especially in the context of international transport. The high sensitivity of flowers to temperature fluctuations, humidity, delivery time and mechanical stress complicates logistics and makes it a responsible process. That is why improving the efficiency of flower transportation is extremely important for preserving their quality and freshness and meeting consumer demands in the global market.

Flowers are perishable goods, so the main conditions for transportation are:

- Temperature control, which is usually maintained between 0 and +4 °C;
- Maintaining optimal humidity levels to prevent drying out or rotting;
- Reliable protection against mechanical damage during transport;
- Minimisation of delivery time to preserve product freshness.

The choice of transport mode and route is crucial for successful delivery. Air transport is most often used for international transport of floral products, as its speed allows for maximum preservation of product freshness. At the same time, road transport is used to deliver flowers to airports or directly to end consumers. When choosing a route, it is necessary to take into account not only geographical distances, but also customs clearance conditions and the availability of the necessary infrastructure for storage and handling of cargo.

To ensure high efficiency in the delivery of flower products, it is recommended to:

1. Develop infrastructure for the storage and handling of flower products at key transport hubs, which will allow the necessary storage conditions to be maintained;

2. Introduce real-time transport condition monitoring systems to control temperature, humidity and other parameters;

3. Improve the qualifications of personnel involved in the logistics of flower products to ensure a professional approach to handling and transportation;

4. Promote international cooperation to simplify customs procedures and speed up the passage of goods across borders;

5. Use modern information technologies to optimise logistics processes, including document flow automation, cargo tracking and route planning.

In general, improving the efficiency of international flower transportation requires a

comprehensive and systematic approach. This includes choosing the most suitable mode of transport to ensure speed and quality preservation, as well as careful planning of all logistics processes, from routing to customs clearance. An important aspect is the control of storage conditions during transportation, which guarantees the maintenance of optimal temperature, humidity and protection from damage. Active cooperation between all participants in the supply chain — producers, carriers, customs services and recipients — contributes to the prompt resolution of possible problems and increases overall efficiency. The introduction of innovative technologies, such as real-time monitoring systems, digital logistics management platforms and process automation, significantly reduces delivery times, lowers operating costs and increases customer satisfaction, which are key factors for success in the international flower market.

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NEXT-GENERATION CONTAINERS IN GLOBAL LOGISTICS

Modern logistics is developing rapidly, and containerized transport remains its foundation. In recent years, new types of containers and technologies have emerged, making cargo transportation more efficient, secure, and environmentally friendly.

One of the main trends is the introduction of smart containers. These containers are equipped with IoT sensors that track location, temperature, humidity, and even door openings in real time. This improves supply chain transparency and reduces the risk of cargo loss or damage. Companies such as Aeler and Maersk are actively implementing these solutions.

Another innovation is foldable (flat-pack) containers, which can be collapsed after unloading and transported in a compact form. This reduces the cost of returning empty containers and saves warehouse space. In addition, more specialized containers are being developed for specific types of goods — such as chemicals, food products, or dry bulk materials.

Environmental sustainability is another major focus. Manufacturers are introducing lighter, recyclable materials and designing containers that help reduce the carbon footprint of transportation. Multimodal logistics is also growing — one container can move across sea, rail, and road without repacking, increasing efficiency across the entire transport chain.

Although the introduction of new technologies requires investments and infrastructure upgrades, the benefits are significant: improved supply chain efficiency, reduced costs, and stronger sustainability. New-generation containers are becoming not just a means of transport but a key element of digital and green logistics of the future.

Innovations in container logistics are not just about changing the shape or material of a container — they represent a comprehensive transformation. Most often, these are intelligent containers adapted for multimodal transport, specialized for specific types of cargo, and focused on sustainability. These developments open up new opportunities for optimizing supply chains and improving the reliability of transportation.

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MODERN TRANSPORT TECHNOLOGIES AND EQUIPMENT IN ROAD TRANSPORT MANAGEMENT

The modern transport industry is undergoing rapid transformation due to the active implementation of digital and engineering innovations. Road transport, which remains the most common and flexible mode of transportation, is particularly influenced by these technological changes. The use of modern transport technologies and equipment has become an essential condition for ensuring high-quality management of transportation processes, safety, energy efficiency, and environmental protection.
One of the most important directions of innovation in the automotive transport sector is the implementation of intelligent transport systems (ITS)**.** These systems integrate information and communication technologies with transport infrastructure to improve the safety and efficiency of movement. Through the use of GPS navigation, telematics, automated traffic control, and real-time data exchange, ITS helps to optimize traffic flow, reduce congestion, and prevent accidents. Such technologies also allow dispatchers to monitor the location and technical condition of vehicles, which ensures reliability and timely delivery of goods and passengers.

Another crucial trend is the digitalization of logistics and transport management**.** The introduction of automated information systems makes it possible to plan routes more accurately, analyse traffic data, and track cargo at every stage of transportation. Online communication between drivers, dispatchers, and clients increases the transparency of logistics operations and minimizes human errors. Predictive maintenance systems, based on data from sensors and onboard diagnostics, reduce downtime and extend the service life of vehicles.

A significant challenge of modern transport is environmental sustainability. The transition to eco-friendly and energy-efficient vehicles — such as electric and hybrid cars — helps reduce harmful emissions and dependence on fossil fuels. The use of renewable energy and lightweight materials also contributes to reducing the carbon footprint of the transport industry. Many companies are investing in charging infrastructure and battery recycling technologies to support this ecological transition.

The next stage of development is the integration of artificial intelligence (AI) and big data analytics into transport management. These tools allow for forecasting traffic demand, optimizing fleet usage, and ensuring dynamic route planning based on current conditions. AI systems can analyze driver behavior, improve safety, and assist in making strategic decisions in complex traffic situations.

In conclusion, modern transport technologies and equipment are not only tools for improving efficiency but also key factors in sustainable development. Their integration into road transport management ensures better quality of services, environmental protection, and competitiveness in the global market. The future of road transport lies in innovation, intelligent systems, and responsible management aimed at creating a safer, cleaner, and more connected world.

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SECTION 2.
ADVANCEMENTS, PROBLEMS, AND PERSPECTIVES OF ENGINEERING

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MODERNIZATION OF AUXILIARY ELECTRIC MACHINES OF ELECTRIC ROLLING STOCK

Today, Ukrainian railway transport needs a modernization stage. Modernization of auxiliary electric machines of electric rolling stock is a topical topic of discussion, since the reliability and efficiency of trains depend not only on traction motors, but also on auxiliary systems that ensure their operation.

Most auxiliary machines operated today have an outdated design, high energy losses and require frequent maintenance.

In this regard, it is advisable to switch to modern asynchronous and brushless electric motors with frequency regulation, which allows: to reduce electricity consumption by 20–30%; increase service life and reduce repair costs; improve the dynamic characteristics of power supply systems; ensure integration with microprocessor train control systems.

An important element of modernization is the introduction of diagnostic and monitoring systems for the condition of electrical machines. Modern microprocessor controllers can monitor parameters such as temperature, current, vibration, noise level and analyze deviations from normal operation. This allows you to predict possible failures, prevent accidents and switch to a maintenance system based on technical condition, rather than a calendar schedule.

The implementation of such solutions is particularly relevant in the context of energy independence and environmental sustainability of the transport sector, as reducing electricity consumption directly reduces operating costs and carbon footprint emissions during energy generation. Therefore, the modernization of auxiliary electric machines of electric rolling stock is an important step towards creating intelligent, energy-efficient and reliable transport systems. It combines electrical, information and energy-saving technologies, forming the basis for the further development of electric transport in Ukraine and the world.

The modernization of auxiliary electric machines on locomotives such as VL80, ChS4, and EP1M demonstrated the following improvements:

Increase of machine lifetime by 30–50%.

Reduction of maintenance costs by up to 25%.

Decrease in vibration and noise levels by 15–20%.

Improvement in overall locomotive reliability and energy balance.

Additionally, digital control integration enabled real-time monitoring of machine parameters (temperature, vibration, current) and predictive maintenance planning, which reduces unscheduled downtime.

Modernization of auxiliary electric machines is a crucial step toward sustainable and energy-efficient railway systems. The transition to modern AC drive technologies, intelligent control, and advanced materials significantly enhances the technical and economic performance of electric rolling stock.

Future development should focus on full digital integration of auxiliary systems within the onboard diagnostic network, use of modular designs, and the application of predictive algorithms for maintenance and energy optimization.

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ACHIEVEMENTS: A LEGACY OF INNOVATION

Engineering is not just a profession; it is the foundation upon which the modern world is built. It is the practical application of science and mathematics to solve complex problems and innovate for the betterment of society.

The history of engineering is a catalogue of monumental achievements that have fundamentally reshaped human existence.

Infrastructure and mobility: civil and mechanical engineers gave us safe water supply and distribution systems, which drastically increased life expectancy, and the revolutionary transportation networks: the automobile, the airplane, and extensive highway systems. These feats of engineering spurred globalization and connected the world.

The digital age: electrical and computer engineering ushered in the digital revolution. the development of electronics (from vacuum tubes to transistors), the computer, and most notably, the internet, transformed communication, information dissemination, and commerce.

Energy and health: electrification created vast power networks, while engineering innovations in medicine, such as medical technologies and the mass production of antibiotics, have saved countless lives. Furthermore, the development of air conditioning and refrigeration not only provides comfort but is vital for preserving food and medicines. These achievements are not isolated; they are interconnected, with innovations in one field often propelling developments in others.

Current challenges: designing a sustainable future despite these triumphs, engineering faces significant and urgent global challenges, demanding a shift towards more ethical and sustainable practices.

Climate change and sustainability: this is perhaps the greatest challenge. engineers are tasked with mitigating the climate crisis by developing sustainable and viable renewable energy sources (solar, wind, tidal), designing net-zero buildings, and improving energy efficiency across all sectors. The focus must be on green engineering to reduce the carbon footprint of manufacturing and construction.

Infrastructure resilience: in many developed nations, the aging infrastructure (roads, bridges, water, and electrical systems) requires significant overhaul and modernization to ensure safety and functionality.

Global access to resources: ensuring a clean and accessible water supply for all, especially in developing regions, remains a critical engineering problem that requires innovative, context-specific solutions, such as advanced desalination and smarter water distribution systems.

Workforce evolution: the engineering field faces a persistent skills shortage and a lack of diversity. education systems need to incorporate more digital engineering, lifelong learning, and emphasize multidisciplinary skills like ethics, management, and collaborative communication, often referred to as stem integration.

Prospects: the horizon of engineering the future of engineering is one of profound digital and environmental transformation, offering exciting prospects and new, high-demand specializations.

Digital transformation: emerging fields are dominated by artificial intelligence (ai), machine learning, robotics and automation engineering, and cybersecurity. engineers will be pivotal in managing autonomous systems, designing software-defined vehicles, and developing digital twins (virtual replicas) to optimize real-world systems.

Biotechnology and health: biomedical engineering will continue to advance, focusing on areas like genetic counselling, developing high-tech prosthetics, and even using bio-ink for 3d printing of tissues.

Renewable energy and smart infrastructure: demand will grow for smart grid engineers and specialists in renewable energy engineering to design intelligent, decentralized power networks and resilient, sustainable urban infrastructure, including smart cities.

Interdisciplinarity: the future engineer will need to be a holistic problem-solver, blending

traditional engineering knowledge with a plethora of digital skills (data management, cybersecurity) and a strong commitment to ethical and sustainable design.

In conclusion, engineering has given us the world we inhabit, but it is the key to solving the critical challenges of tomorrow. the next generation of engineers will be defined by their ability to innovate sustainably, ethically, and collaboratively.

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RUNNING A WOODEN PATTERN-MAKING BUSINESS FOR FOUNDRY PRODUCTION IN DNIPRO DURING WARTIME

Dnipro has always been one of Ukraine’s main industrial cities – a place where machinery, metal, and hard work go hand in hand. Among its many small enterprises, there are workshops that make wooden patterns and moulds for foundry production – the parts used to shape molten metal into engine details, gears, or construction elements. It is a craft that combines technical skills, precision, and a real love for making things by hand.

Since the war began, however, running this kind of business has become a daily challenge. It is getting harder to find the right materials – quality hardwood, resins, and metal fittings. Deliveries that used to take a few days can now take weeks, and prices for tools and imported machine parts have doubled or even tripled. Entrepreneurs often have to improvise: repair old equipment, use local materials, or share resources with other small workshops just to keep working.

Power cuts are another big problem. When electricity stops in the middle of machining, the workpiece can be ruined – and that means lost money and time. Many workshop owners have had to buy generators or backup batteries, though those too are expensive and hard to maintain.

Still, the people of Dnipro don’t give up easily. Many of the city’s new business owners are internally displaced people — men and women who lost their factories, tools, and homes in places like Henichesk, Melitopol, or Tokmak. Having lost almost everything, they came to Dnipro and started over from scratch. Some rent tiny workshops in old industrial zones; others team up with local craftsmen to share space and machinery. What unites them is resilience – and the belief that work gives strength and purpose.

These displaced entrepreneurs bring valuable technical experience and knowledge of foundry technologies. Their new enterprises not only contribute to the local economy but also help restore production capacities crucial to Ukraine’s industrial resilience. Some of them cooperate with volunteer and defence-related initiatives, producing custom metal components or repair parts for machinery used by the Ukrainian Armed Forces and humanitarian organizations.

They see their work not only as a way to survive, but also as a small contribution to the country’s defence and recovery.

Support from local authorities, volunteers, and international programs helps too – with small grants, training, and networking opportunities. But in the end, it is the people themselves who make the difference. Their persistence, creativity, and hands-on experience show how much can be achieved even in the hardest times.

In Dnipro’s workshops, anyone can hear the hum of machines, smell fresh-cut wood, and feel the quiet determination of people who simply refuse to stop working – no matter what.

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MODERN MODULAR MULTI-LAYER SHELTERS

Modern military operations are characterised by their dynamic nature, the variety of threats involved, and the growing demand for the mobility of engineering units. One of the key issues is the limited survivability and slow deployment of traditional shelters in field conditions, which reduces the effectiveness of protecting personnel and combat equipment. Such shelters play an essential role in ensuring safe living conditions for soldiers during service and field training. Modern engineering practice has achieved a new generation of modular, multilayer shelters that combine high levels of protection and technological flexibility with speed of deployment. The shelters consist structurally of multi-layer panels, each of which performs a separate function: the power layer provides mechanical strength to the structure; the energy-absorbing layer reduces the impact of shock and fragmentation loads; the thermal insulation layer maintains operating conditions; and the camouflage layer reduces visual and thermal visibility. The modular architecture allows quick configuration changes depending on the terrain, type of threat and mission objectives, simplifying transportation, assembly and disassembly.

In addition to underground bunkers and missile silos, all military facility buildings and structures can be constructed from block modules. Modular shelters can be used in stationary or mobile conditions. Stationary buildings in military towns, such as barracks, dormitories, canteens, training buildings and infirmaries, are equipped with all the necessary engineering systems to provide life support and comfort throughout the year. Mobile block containers for headquarters, command posts and communications units are designed for specific tasks. They do not require foundations and can be equipped with autonomous life support and power supply systems, increasing their operational efficiency and independence from infrastructure.

Modern materials include multilayer panels made of polymers, metals, and composite structures, which provide an optimal balance of strength, weight, and resistance to aggressive environments. Integrating sensor systems enables real-time monitoring of the structure condition, and autonomous modules provide rapid protection reinforcement when needed. This approach increases the adaptability of shelters, allowing them to be used effectively in various combat conditions and ensuring the operational readiness of engineering units.

Development of modular, multilayer shelters hinges on the introduction of new materials and design solutions, the digital modelling of adaptive protection systems and their integration with automated engineering platforms. Possibilities being explored include the use of lightweight composite materials with increased energy absorption properties, remote monitoring systems for structural condition, and rapid response to threats, as well as integration with military facility security management systems.

In conclusion, we can state that the next generation of modular multilayer shelters enhances the operational readiness of engineering units, improves the personnel and equipment protection, and paves the way for the development of innovative adaptive solutions in the field of engineering security.

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CAR TURBOCHARGER REPAIR AS A SMALL BUSINESS IN DNIPRO

In the industrial city of Dnipro, small businesses engaged in car turbocharger repair have become an important part of the local service economy. These enterprises combine technical expertise with entrepreneurial resilience, operating in a market that requires precision, speed, and adaptability. Turbochargers are critical components of modern vehicles, enhancing engine efficiency and reducing fuel consumption, but their repair demands high technical skills, specialized tools, and access to quality spare parts.

For small workshops, the wartime environment has created a number of serious challenges. Supply chain disruptions and delays in imports make it difficult to obtain original or certified replacement parts. Many business owners have adapted by refurbishing used components, restoring damaged turbines, and even producing small parts on their own using 3D printing or CNC machines. This creativity allows them to remain competitive despite limited resources.

Energy instability is another major issue. Frequent power outages and rising electricity costs have forced many workshops to invest in generators, solar panels, or backup batteries. These additional expenses significantly increase the cost of doing business. Nevertheless, the demand for turbocharger repair services remains high, as the economic situation encourages drivers to maintain and repair vehicles rather than purchase new ones.

An important feature of Dnipro's entrepreneurial landscape is the growing number of businesses initiated by internally displaced persons – entrepreneurs who lost their enterprises in temporarily occupied territories and decided to rebuild their livelihoods from scratch. Many of them arrived in Dnipro from cities such as Mariupol, Melitopol, or Berdiansk, bringing valuable experience, equipment, and professional skills. Although they often faced the loss of property, tools, and customer bases, these individuals have managed to re-establish new workshops in Dnipro's safer industrial zones. Local business communities and volunteer networks have provided assistance with workspace, logistics, and sometimes even initial funding. These new enterprises not only support the local economy but also contribute to social recovery and employment for displaced specialists.

Many of these small repair businesses also play a crucial role in supporting the Ukrainian Armed Forces. Their technical expertise and access to specialized equipment enable them to assist in repairing and restoring military vehicles, generators, and other machinery used on the front lines. Some workshops collaborate with volunteer organizations to provide fast, high-quality repairs free of charge or at reduced cost, viewing this contribution as part of their civic duty. This dual mission – maintaining economic activity while helping the defence effort – has strengthened the reputation of Dnipro's technical entrepreneurs as both skilled professionals and committed patriots.

Despite all difficulties, turbocharger repair workshops in Dnipro symbolize adaptability, resilience, and solidarity. They demonstrate how determination, technical skills, and community spirit can rebuild livelihoods and support national defence even in the face of war.

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THE ACHIEVEMENTS, PROBLEMS AND PROSPECTS OF ENGINEERING IN THE FOOD TECHNOLOGY SECTOR

The engineering field plays a key role in the development of food technologies, providing innovative solutions for the production of safe, high-quality and functional food products. In today's world of globalisation and increasing food safety requirements, engineering approaches to modernising technological equipment, improving energy-saving processes and introducing digitalisation into

production are becoming increasingly important.

Modern engineering solutions contribute to the automation of food enterprises, minimisation of the human factor, and improvement of product quality control. Intelligent manufacturing technologies (Industry 4.0) are actively developing, involving the use of cyber-physical systems, sensor monitoring, robotics, and artificial intelligence to optimise food processes.

A significant achievement is the introduction of highly efficient food processing technologies: high pressure processing (HPP), pulsed electric field (PEF), freeze drying, etc. These methods ensure the preservation of nutritional value and extend the shelf life of products without the use of artificial preservatives.

In addition, the production of alternative foods is actively developing — plant protein, lab-grown meat, and products using microalgae. This reduces the burden on natural resources and is in line with the concept of sustainable development. Biotechnology is also of great importance, where fermentation process engineering contributes to the creation of innovative functional products with probiotic properties.

Despite significant technological advances, the food industry faces a number of challenges. First, there are high costs for modernising equipment and introducing innovations, especially for small and medium-sized enterprises. Second, there is the problem of ensuring sufficient food security amid global environmental and economic changes. There is also a shortage of highly qualified engineering personnel in the food sector who are capable of working with the latest technologies, digital systems and automated complexes.

A separate issue is the environmental aspect of production — the generation of large amounts of waste and the consumption of water and energy resources. To address these challenges, it is necessary to implement the principles of the circular economy, recycle by-products, use renewable energy sources and environmentally friendly packaging.

The future of engineering in food technology is linked to further automation and robotisation, the development of green technologies, and intelligent resource management. One promising area is personalised nutrition, which involves adapting products to individual human needs. 3D printing technologies for food products and real-time sensory quality analysis systems will become widespread. The use of blockchain technologies to ensure complete transparency of the food chain — from producer to consumer — will become a priority.

Thus, modern engineering in the field of food technology is undergoing a period of active transformation aimed at achieving innovation, environmental friendliness and safety in food production. Solving existing problems will help to increase the competitiveness of the food industry and strengthen food security at the national and global levels.

SECTION 3. MODERN ECONOMIC PROBLEMS AND THE WAYS OF SOLVING THEM

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DIGITAL PLATFORMS AS A TOOL TO COUNTERACT THE SHADOWING OF THE ECONOMY

The shadow economy is a major problem for many countries, including Ukraine. It includes all business activities that are not registered with the government. This means that people and companies do not pay taxes, and workers do not have social protections. Because of this, the state loses money for important things like hospitals and roads, and honest businesses face unfair competition.

In today's world, digital platforms are becoming a powerful tool to fight this problem. Digital platforms are websites or mobile apps that connect people to buy, sell, or offer services. In Ukraine, we see great examples of this. For instance, the OLX and Rozetka platforms allow thousands of individuals and small businesses to sell goods officially. The Bolt and Uber apps formalise taxi rides, and the Hizha service helps people find and legally rent rural homes for vacation. These platforms help make the economy more open and official.

They help reduce the shadow economy in several key ways. First, they automatically keep records. Every sale, payment, or service provided through the platform is recorded digitally. This creates a clear history of the transaction that is difficult to hide from tax authorities. Second, they encourage formal payments. Cash payments are very common in the shadow economy because they are hard to track. Platforms, however, mostly use electronic payments like bank transfers or credit cards. For example, when a customer pays for a book on Rozetka via card, or for a Bolt ride through the app, this money is recorded. This makes the movement of money visible and easy to monitor.

Third, they build trust through rating systems. Users can rate sellers or service providers. To get good ratings and attract more customers, businesses are encouraged to be reliable and operate officially. Finally, these platforms can be easily connected to government tax systems. This allows for the automatic reporting of income, making tax evasion much more difficult.

To understand this better, a small survey was conducted among 30 small business owners in Ukraine who use digital platforms like OLX or Prom.ua. They were asked if using a platform makes it easier to report their income to the government. The results showed that 70% of respondents said it is much easier, 20% said it is the same, and only 10% said it is more difficult. This small study suggests that most business owners find that digital platforms simplify their official financial reporting because the platforms provide clear records of their income.

However, using digital platforms is not a perfect solution. There are some challenges. Not everyone has the skills or access to use these platforms, which can leave some people out. Also, the government needs to create clear laws that require platforms to share data with tax authorities, for example, through the new system of electronic cash registers.

In conclusion, digital platforms are a very effective modern tool for managing the economy and reducing its shadow sector. They make business more transparent through automatic digital records, electronic payments, and trust-building rating systems. For the future, it is important for managers and the government to support the development of digital platforms and create smart laws that help them fight the shadow economy effectively.

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EFFICIENCY OF REMOTE AND HYBRID WORK MODELS IN UKRAINE

The world of work has changed significantly in recent years, with remote and hybrid models becoming common. For Ukraine, these changes are especially important because of the need for flexible and stable work during the war. This research looks at how effective these new work models are for Ukrainian companies.

Remote work means employees work fully from home or another location outside the office. Hybrid work combines days in the office with days working remotely. Many Ukrainian businesses in sectors like IT, marketing, and consulting have started using these models. The main question is whether they help or hurt productivity.

There are several important benefits of remote and hybrid work. First, they can lead to higher productivity. Many employees report getting more done at home because there are fewer distractions from colleagues and meetings. Second, they save time and money because people do not need to travel to the office. This is very useful in big cities like Kyiv or Lviv with traffic problems. Third, these models give employees more freedom to manage their time, which leads to higher job satisfaction. Companies can also save money on office space and hire talented people from different parts of the country.

However, there are also challenges. One big problem is communication. It can be harder to collaborate and share ideas quickly when the team is not in the same room. Another issue is the blurring line between work and personal life, which can cause stress and burnout. Some employees may also feel isolated or disconnected from their team and company culture. From the manager's side, it can be difficult to monitor performance and ensure everyone is working effectively.

To maximise the benefits and overcome the difficulties, companies need to change their management style. Old methods of control are less effective. Success now depends on managing by results, not by observing the process. This requires more trust in employees, clear goals, and the use of special digital tools for project management and communication.

For Ukraine, these models have specific importance. During the war, they provide business continuity. Companies can keep operating even during air alarms or if employees have to move to safer places. They also help the economy by allowing people to keep their jobs and salaries. Furthermore, they make Ukrainian companies more modern and competitive on the global market.

In conclusion, remote and hybrid work models are powerful tools for modern management in Ukraine. They offer clear benefits like increased productivity, cost savings, and greater flexibility, which are crucial during wartime. However, managers need to solve problems like communication gaps and employee well-being. The future of work in Ukraine will likely be a smart mix of remote and office work. For success, companies should invest in good technology, train their managers for remote team leadership, and focus on building trust with their employees.

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MODERN TRENDS IN THE DEVELOPMENT OF THE HOTEL AND RESTAURANT BUSINESS IN UKRAINE

Trends in the restaurant and hotel business are modern directions of development of the industry and current trends that affect the functioning, organization of work and service in the hospitality sector

and determine the distribution of hotels and restaurants today and in the future.

The hotel and restaurant business is one of the most important and dynamically growing areas of the modern economy. The hospitality industry brings improvements both in the social direction (rest and improvement of people's health) and in the economic direction (increasing the profit of the country's economy). [1]

This type of business brings the greatest economic profit to tourist regions, contributes to the development of entrepreneurial activity. The services of the industry are always relevant, even during a crisis in the country or in the economy, people find time for rest and relaxation.

Trends in the hotel and restaurant business consist in providing people with quality rest to restore psychological and physical health, safe and comfortable living conditions, as well as in improving technological processes when serving guests. Improving innovative technologies, posting the establishment's page on social networks, publishing rooms of various categories, from economy class to presidential or luxury rooms, photos of the establishment's premises on the Internet, descriptions of services offered by the hotel or restaurant, price reviews, discounts. By the way, cooperation with bloggers also gives a great deal of awareness to the hospitality establishment. Multimedia technologies and the use of digitalization help to quickly and effectively obtain information about the hotel or restaurant, presenting the full range of services, assessing the advantages and choosing the best place to relax, some leisure establishments use virtual tours and make 3-D presentations of rooms [2].

The introduction of chatbots, mobile applications, online booking greatly simplifies the registration procedure and provides quick communication with the hospitality establishment.

Perhaps the main task of development trends is innovation in the restaurant sector. Improving and expanding the range of products. It is advisable to introduce healthy and seasonal dishes, to compare gluten-free menus, to meet the needs of a diverse contingent of consumers, vegan dishes. Trending products in restaurants remain ancient grains (quinoa, amaranth, teff, sorghum, millet, spelt), which are beneficial for health. It is very important to always improve technology, thus obtaining new recipes [3].

Today, delivery of cuisine "to go" to any point is very popular. If a food product is constantly being improved and has a diverse range, there will be a greater demand for it, and therefore, it will be possible to retain consumers. It is advisable to increase the level of service and an individual approach to customers, it is worth introducing discounts to retain customers, customers feel the benefit, using the All inclusive service system, where the guest pays for the stay once and can get most of the services (three meals a day, snacks and drinks during the day, use of the pool, sports activities, entertainment.

Domestic and event tourism is developing more and more actively, people travel and get acquainted with cultural attractions, visit new cities and regions. Event tourism – travel associated with visiting exhibitions, conferences, sporting events, festivals. Also a popular area of business tourism is MICE tourism, which includes visiting business events, conferences, corporate parties. So, the hotel and restaurant business is actively developing and is influenced by changes in the market environment, changes in consumer preferences and needs, and the technological process. The main trends in this area include loyalty in service, digitalization of services, improvement of service quality, development of event and domestic tourism, attraction of multifunctional formats. These trends contribute to meeting consumer needs, forming a positive image of hospitality establishments and increasing the competitiveness of enterprises.

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THE EFFECTIVENESS OF DIGITAL MARKETING TOOLS IN PROMOTING TOURIST DESTINATIONS

In the modern world, digital marketing has become extremely important for the tourism industry. It has changed how places attract visitors and communicate with them. For tourist destinations, using digital tools is no longer just an option but a necessity to stay competitive. This report examines how effective these digital marketing tools are in promoting tourist destinations to potential travellers.

Digital marketing includes all forms of online promotion. The main tools are social media platforms, search engine optimisation, content marketing, and online advertising. Social media platforms like Instagram, Facebook, and TikTok are particularly powerful for tourism because they are visual. Beautiful pictures of landscapes, historic sites, and local food can inspire people to visit a place. These platforms also allow for direct communication through comments and messages, helping build a relationship with potential tourists.

Another important tool is having a good website that is easy to find through search engines like Google. This process is called Search Engine Optimisation or SEO. When someone searches for "best beach vacation" or "historical cities in Europe," a well-optimised website will appear at the top of the results. The website should be attractive, easy to use, and provide all necessary information like accommodation options, transportation, and main attractions.

Content marketing is another effective approach. This includes travel blogs, videos, and articles that tell interesting stories about a destination. Instead of directly advertising, this method provides valuable information and entertainment. For example, a blog post about "10 Hidden Gems in Paris" or a video showing a day in the life of a local guide can be very engaging and persuasive for potential tourists.

Online advertising through Google Ads or social media platforms allows destinations to target specific groups of people. A mountain resort can show ads to people interested in hiking, while a city known for its art museums can target culture enthusiasts. This precision makes advertising more effective and cost-efficient compared to traditional methods like television or newspaper ads.

The advantages of digital marketing are significant. It has a global reach, allowing even small or lesser-known destinations to attract international visitors. It is generally more affordable than traditional marketing, which is especially important for destinations with limited budgets. The results are also measurable - we can track how many people saw an advertisement, visited a website, or made a booking based on a digital campaign.

In conclusion, digital marketing tools have proven highly effective in promoting tourist destinations in today's connected world. They offer unprecedented opportunities to reach global audiences, engage with potential visitors, and measure the success of marketing efforts. While requiring specific skills and constant attention, these tools have become essential for any destination wanting to succeed in the competitive tourism market. The future of destination marketing will undoubtedly see even greater integration of digital technologies, making it an exciting and evolving field for tourism professionals.

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THE CURRENT ECONOMIC PROBLEMS AND WAYS TO SOLVE THEM IN THE HOTEL AND RESTAURANT INDUSTRY

The hotel and restaurant industry is one of the most dynamic sectors of the global economy. It generates a significant share of revenue in many countries, creates jobs and stimulates the development of related industries, including transport, agriculture, food production and socio-cultural services. However, current economic challenges are significantly affecting its functioning and competitiveness in our country.

It is worth noting the complex problems of tourism and hotel and restaurant business development in Ukraine, namely: non-compliance with international norms and standards of state regulation and service in the industry; imperfect legislation on tourism, hotel and restaurant business; lack of effective state support for small and medium-sized tourism and hotel and restaurant businesses; insufficient number of highly qualified personnel; insufficient state funding for tourism and hotel and restaurant businesses due to underestimation of the potential of these industries; failure to comply with the current Strategy for the Development of Tourism and, in particular, the development of the hotel and restaurant business, its imperfection, irrational monitoring; a decrease in the number of foreign tourists in the regions due to the general unstable situation in the east of the country; and the most important problem today - the crisis situation in the context of the war in Ukraine.

The financial stability of hotel and restaurant businesses requires particular attention, as a significant number of establishments are forced to cut back on investment in development, marketing and innovation.

According to our analysis, we have found that quality issues play a crucial role in the provision of hotel services. Without high-quality service, a hotel cannot achieve its main goals. Global practices in the development of various hotel corporations and chains generally show that profitability is the result of high-quality service.

There are a number of specific features of hotel services that allow for flexibility in terms of quality, lowering or raising standards for different categories of consumers based on their needs and purchasing power.

An important role in the prosperity of a hotel enterprise is played by personnel policy (the availability of highly qualified personnel); financial and material and technical support; innovative directions and methods of work; compliance with the conditions of sustainable development (which is extremely relevant in modern conditions).

Today, the hotel sector faces the pressing issue of attracting guests, primarily by improving the quality of service, including through staff training, as most Ukrainian hotels neglect service rules and standards.

The challenges can be effectively overcome by implementing modern management tools and innovative approaches, including the digitisation and automation of accounting and service processes, and the optimisation of logistics and partner deliveries. Focus on developing environmentally friendly services, such as green hotels, energy-efficient technologies, and minimising food waste. Strengthen marketing in the digital environment, personalised loyalty programmes, and invest in training and staff development.

It should be noted that companies that actively implement innovative business models show more sustainable recovery dynamics after crises. Improving resource management efficiency, introducing digital and energy-saving technologies, and developing human capital are key areas for improving the industry's competitiveness in the future.

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CHALLENGES OF OPERATING A VITAMIN CAFÉ IN DNIPRO DURING WARTIME

Operating a vitamin café in Dnipro, a city known for its industrial character, active youth culture, and growing health awareness, has become a demanding business venture under wartime conditions. Vitamin cafés typically focus on promoting a healthy lifestyle through freshly prepared smoothies, protein shakes, natural juices, and balanced snacks. However, the combination of economic instability, logistical difficulties, and social stress has created numerous barriers to sustainable operation and growth.

One of the most serious problems is the decline in consumer purchasing power. The ongoing war has led to a significant reduction in household income, forcing customers to prioritize essential goods over wellness-oriented products. Items such as protein powders, almond milk, chia seeds, or imported fruits have become luxury goods for many Ukrainians. Rising prices for raw materials, rent, and utilities have also pushed up production costs. As a result, many cafés are forced to increase prices, which further reduces customer demand.

Supply chain disruptions are another persistent challenge. Due to damaged logistics networks and limited imports, owners often struggle to maintain a stable supply of fresh or exotic ingredients. Deliveries from southern regions and foreign suppliers are unpredictable, and import duties have risen. To cope, many cafés shift toward locally sourced and seasonal products - apples, beets, carrots, berries, and herbs from Ukrainian farmers, highlighting “farm-to-table” or “eco-friendly” concepts. While this adaptation supports local producers, it restricts menu variety and sometimes limits the café’s appeal to fitness enthusiasts used to international nutritional trends.

Energy instability adds further complexity. Power outages interrupt the use of refrigerators, blenders, juicers, and espresso machines, directly affecting product quality and service speed. To maintain operations, café owners invest in generators, energy-efficient appliances, and portable lighting systems. However, these measures increase operating expenses and require additional maintenance and safety measures.

Staff management has also become more difficult. Many young employees have relocated or joined volunteer and defence efforts, leading to staff shortages. Remaining workers often experience stress, uncertainty, and burnout. Maintaining motivation and customer service quality under such circumstances demands strong leadership and emotional resilience from business owners.

A distinctive feature of Dnipro’s business landscape during wartime is the growing number of enterprises founded by internally displaced persons, entrepreneurs who lost their cafés or health-food shops in temporarily occupied territories such as Mariupol, Melitopol, and Tokmak. These individuals have restarted their businesses in Dnipro, often with minimal resources, relying on experience, community support, and sheer determination. As a result, many of these cafés not only contribute to the city’s economy but also symbolize recovery and resilience for displaced communities.

Government and local initiatives also play a role in supporting such businesses. Through municipal small business funds, entrepreneurs can apply for microgrants to purchase new equipment or expand production.

Despite all obstacles, vitamin cafés in Dnipro continue to serve as symbols of resilience and optimism. They not only promote healthy lifestyles but also foster a sense of normalcy and community, showing how small businesses can adapt creatively, support local economies, and contribute to social wellbeing even in times of war.

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THE ROLE OF MIGRATION IN HOST COUNTRIES' ECONOMIES: BENEFITS AND RISKS

Migration is one of the most significant socio-economic phenomena of the 21st century. Millions of people move across borders every year in search of better employment opportunities, education, safety, and improved living standards. While migration is often discussed in political or social terms, its economic impact on host countries is equally crucial. Migration brings both benefits and challenges, influencing labor markets, fiscal systems, productivity, and long-term economic growth [2].

One of the most visible effects of migration is on the labor market. Migrants often fill positions in sectors where there is a shortage of domestic workers, such as agriculture, construction, healthcare, and hospitality. This helps reduce labor gaps and ensures that essential industries function smoothly. In many cases, migrants are willing to take jobs that locals avoid, thereby complementing rather than replacing the native workforce. However, sudden increases in migration flows can also create short-term competition for low-skilled jobs, potentially leading to wage pressure [1].

Migrants also show high rates of entrepreneurship, founding small and medium-sized firms that create jobs and expand local supply chains. These enterprises often serve niche markets, diffuse new business practices, and stimulate competition, which can raise productivity for incumbent firms. Access to finance and streamlined licensing amplify these effects [3].

Effects on native workers differ by skill. Over time, migrants more often complement high-skilled natives, raising their productivity through task specialization and knowledge spillovers. Short-run wage shifts concentrate in low-skill segments and are mitigated by training and mobility investments [2].

Regional impacts are uneven. Large cities with diversified economies absorb migrants faster through thicker labor markets and denser service networks, while small towns face sharper pressure on housing and schools. Spillovers matter: migrant spending boosts local demand for retail, transport, and services, which can offset initial wage competition in low-skill segments over time [4].

Migrants contribute to public finances through taxes, social security payments, and consumption. Assess fiscal impact over the life cycle. Upfront integration costs can exceed revenues, but within a few years employment and earnings rise and contributions to taxes and pensions turn positive. The horizon and assumptions (employment, fertility, return rates) materially change results[1,5]. Young, working-age migrants are especially beneficial, as they often pay more in taxes than they receive in public benefits, at least in the short to medium term. This can help host countries address demographic challenges, such as aging populations and shrinking workforces. On the other hand, if migration includes a significant number of dependents or refugees, the fiscal burden may increase due to higher spending on education, healthcare, and social assistance [5].

Migration can stimulate productivity growth. Skilled migrants bring new knowledge, expertise, and innovative ideas, which may enhance competitiveness in science, technology, and business. For example, research has shown that migrants have contributed significantly to the development of high-tech industries in the United States and Europe. Furthermore, cultural diversity can foster creativity, leading to more dynamic and adaptable economies.

Innovation networks matter. Migrants link host firms to global knowledge hubs, raising patenting rates and speeding diffusion of frontier practices. University-industry ties and researcher visas amplify these spillovers [4].

Diaspora and brain circulation amplify gains. Expat communities lower information frictions, expand trade and FDI channels, and transmit managerial know-how back to host and origin economies. Circular migrants often return with upgraded skills and networks, reinforcing two-way innovation linkages [3].

In the long run, migration tends to support economic growth by expanding the labor force and increasing demand for goods and services. Migrants not only work but also consume, creating new markets for businesses. Additionally, remittances sent back home often strengthen economic ties

between host and origin countries, fostering trade and investment. Nonetheless, successful integration policies are critical to maximizing these long-term benefits. Poorly managed migration can lead to social tensions, labor market segmentation, and underutilization of migrant skills [2].

Policy levers determine outcomes. Fast credential recognition, language training, and targeted job-matching speed participation and reduce skills underutilization; housing supply and anti-discrimination enforcement limit crowding and segmentation. Data-driven funding formulas that follow people, not places, align fiscal transfers with actual service use and improve public acceptance[5].

Intergenerational outcomes are pivotal. With equal access to quality schools and early-language support, children of migrants converge toward or surpass native outcomes in education and earnings, lifting long-run productivity and net fiscal contributions. Barriers in tracking, streaming, or credentialing delay these gains [4].

Housing and urban planning are binding constraints. Where zoning is rigid and supply slow, inflows raise rents and commute times; where supply is elastic, impacts on prices are muted and agglomeration gains dominate. Earmarking infrastructure funds to fast-growing areas improves net benefits [3].

Despite clear benefits, migration also brings challenges: housing strain, pressure on services, and integration hurdles. Governments should balance policy, fund integration, and ensure equal access to education and jobs. Well-managed migration turns risks into opportunities for sustainable growth.

To sum up, migration's economic impact on host countries is complex. Despite short-term strains like labor competition and fiscal pressure, the long-term effects are usually positive: larger labor supply, more innovation, and greater dynamism. Results hinge on policy and integration; in a connected world, migration is not just a social issue but a driver of growth.

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FISCAL DECENTRALIZATION AND ITS IMPACT ON THE ECONOMIC DEVELOPMENT OF TERRITORIAL COMMUNITIES

Fiscal decentralization is regarded as a cornerstone of the contemporary system of public finance, as it determines how authority over financial resources, tax revenues, and expenditure obligations is distributed among different tiers of government. It operates through a network of intergovernmental fiscal relations that regulate financial flows, institutional mechanisms, and the sharing of fiscal responsibilities between national and local entities. In essence, the quality of public finance management depends on whether decision-makers possess sufficient knowledge about the specific priorities and demands of their local populations.

The theoretical foundations of fiscal decentralization were established by prominent scholars such as R. Tiebout, R. Musgrave, and W. Oates. Tiebout's model of *"voting with one's feet"* posits that individuals and enterprises naturally gravitate toward jurisdictions offering the most advantageous ratio of taxation to service quality. Musgrave, within his framework of public finance, distinguished between three fundamental roles of fiscal policy — allocation, distribution, and stabilization — emphasizing that the allocative function should predominantly occur at the local level, where authorities are closer to citizens and can better understand their needs. Oates, in his seminal theory of fiscal federalism, argued that decentralized systems minimize informational asymmetries, since local governments are better

equipped to assess the real situation within their territories. [1].

Empirical studies reveal that fiscal decentralization is not a uniform process but a complex multidimensional reform with both benefits and potential drawbacks. On the positive side, it promotes the efficient use of budgetary resources, enhances the accountability of authorities, expands citizen participation, and encourages competition among regions. Conversely, an unbalanced decentralization process may intensify inequalities between affluent and less developed territories, and the absence of strong control mechanisms can lead to financial mismanagement or corruption. Therefore, sustainable fiscal decentralization requires a combination of local financial independence with effective national oversight, fiscal equalization tools, and transparent audit procedures [2].

Recent international experience shows that the most productive approach involves a moderate model of fiscal decentralization, where local governments possess meaningful autonomy to implement their own development policies, while the central government retains instruments to ensure macroeconomic stability and interregional balance. A successful system must clearly delineate spending responsibilities, establish transparent tax assignments, ensure predictable intergovernmental transfers, and maintain a consistent framework for fiscal accountability.

When effectively implemented and institutionally supported, fiscal decentralization acts as a powerful driver of regional growth rather than a mere budgetary reform. It fosters more rational resource allocation, strengthens local initiative, stimulates entrepreneurship, attracts private investment, and improves the quality of public services. However, the long-term success of this process depends on maintaining a delicate equilibrium between local self-governance and national regulation. Only such a balance can guarantee inclusive, equitable, and sustainable economic development across all territorial communities.

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CHALLENGES OF RUNNING A SMALL BUSINESS IN UKRAINE DURING WARTIME

The war in Ukraine has created an extremely difficult environment for small and medium-sized enterprises (SMEs), which form the backbone of the national economy. Since the beginning of the full-scale invasion, many small businesses have faced unprecedented challenges that threaten their survival and development.

One of the main problems is the destruction of infrastructure and disruptions in supply chains. Damaged roads, blocked ports, and limited access to fuel make it difficult to transport goods and raw materials. Power outages and unstable internet connectivity also impede daily operations, especially for businesses relying on digital tools or e-commerce.

Financial instability is another major obstacle. Many entrepreneurs have lost access to affordable credit, while inflation and currency fluctuations have significantly increased the cost of materials, rent, and utilities. At the same time, consumer purchasing power has declined, forcing businesses to lower prices or shift their focus to essential goods and services.

Human resources are also under strain. A large number of employees have been displaced abroad or mobilized, leading to a shortage of skilled labour. Business owners must also cope with emotional stress and uncertainty about the future, which affects decision-making and strategic planning.

In addition, bureaucratic hurdles and complex tax regulations continue to burden entrepreneurs, despite government efforts to simplify procedures. Cybersecurity risks and the constant need to adapt to new regulations or security threats add another layer of complexity.

The situation in Zaporizhzhia, one of the regions most affected by the war, illustrates these challenges vividly. Many small businesses in the city have been forced to relocate or temporarily suspend their activities due to constant air raids and security risks. Yet, local entrepreneurs continue to demonstrate remarkable resilience: some have reorganized production to supply the military and humanitarian sectors, while others have focused on digital services and remote sales. Business associations and local authorities provide support through training programs, microgrants, and initiatives that help companies adapt to wartime conditions. Despite the proximity to the front line, Zaporizhzhia remains an important industrial and entrepreneurial hub, symbolizing both the vulnerability and strength of Ukrainian small business.

A particularly vivid example of resilience can be seen in Zaporizhzhia, one of Ukraine's frontline regions that has become a refuge for thousands of internally displaced persons. Many of them are entrepreneurs who lost their businesses in temporarily occupied territories such as Melitopol, Berdiansk, or Tokmak. Despite losing property, equipment, and customer networks, these displaced business owners have restarted their activities in Zaporizhzhia, building new enterprises from scratch. Some have reopened cafés, small manufacturing facilities, repair shops, and service centres, often working in shared spaces or cooperative networks. Local authorities, NGOs, and volunteer groups provide support through training programs, business incubators, and microgrants that help displaced entrepreneurs adapt to new market conditions. These businesses not only contribute to the local economy but also serve as symbols of recovery, perseverance, and community solidarity.

Nevertheless, Ukrainian SMEs continue to show resilience and innovation. Their adaptability, creativity, and social responsibility have become key factors sustaining the country's economic stability and contributing to post-war recovery.

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CHALLENGES OF PUBLIC ADMINISTRATION UNDER WARTIME CONDITIONS IN ZAPORIZHZHIA AND DNIPRO

The full-scale Russian invasion of Ukraine has transformed the functioning of public administration across the country, particularly in frontline and near-frontline regions. The cities of Zaporizhzhia and Dnipro exemplify how local governments have been forced to operate under conditions of constant uncertainty, resource shortages, and humanitarian pressure. Their experience highlights both the vulnerability and the adaptability of Ukraine's system of local governance in wartime.

One of the most critical challenges has been maintaining the continuity and effectiveness of administrative functions amid ongoing security threats. Regular operations, such as public service delivery, urban management, and social support, are frequently interrupted by air raids, infrastructure damage, and communication disruptions. Local authorities must often make urgent decisions without complete information, balancing short-term crisis management with long-term recovery planning.

Another significant issue is the management of internally displaced persons. Zaporizhzhia and Dnipro have become major hubs for those fleeing temporarily occupied territories in southern and eastern Ukraine. The inflow of displaced populations has placed enormous strain on local budgets, housing systems, healthcare, and education. Municipal administrations have had to reorganize their structures to coordinate humanitarian assistance, integrate IDPs into the local labour market, and ensure social cohesion under rapidly changing conditions.

Financial constraints represent an additional obstacle. Wartime realities have reduced local tax revenues while substantially increasing expenditures related to emergency response, infrastructure restoration, and social protection. This situation forces local governments to seek alternative funding sources, strengthen cooperation with national authorities, and partner with international organizations and volunteer groups. The need for transparent, flexible financial management has become more urgent

than ever.

The human dimension of governance has also changed. Civil servants in Zaporizhzhia and Dnipro operate under high psychological stress, often working long hours under the threat of missile attacks. Issues of staff burnout, motivation, and ethical responsibility have become central to the effectiveness of administrative work. Leadership now requires not only managerial competence but also emotional resilience and empathy.

Despite these pressures, public administrations in both cities demonstrate a high degree of institutional adaptability. Decision-making has become more decentralized and pragmatic, with stronger coordination among municipal departments, NGOs, and volunteer organizations. In Zaporizhzhia, local authorities work closely with military administrations, balancing civilian governance with security imperatives. Dnipro, in turn, has evolved into a key logistical and administrative centre for the region, accommodating relocated institutions and businesses, and providing a model for resilient urban management.

The wartime experience of Zaporizhzhia and Dnipro illustrates that effective governance under crisis conditions depends not only on institutional capacity but also on human flexibility, trust, and collaboration. These cities show that even in the most difficult circumstances, local administrations can maintain functionality, protect citizens, and contribute to the broader resilience of the state.

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KEY MODERN MARKETING STRATEGIES FOR MANAGEMENT IMPROVEMENT

Implementing modern marketing strategies can improve management for enterprises with foreign investments by focusing on innovation, adapting to market changes, and optimizing operations. Key modern strategies include leveraging digital marketing, enhancing customer relationships through digital channels, and developing agile marketing plans that respond to both external market factors and internal company capabilities. By focusing on market trends, consumer preferences, and innovation, a company can increase its competitiveness and financial performance while also managing risks associated with foreign investment.

Key modern marketing strategies for management improvement:

- Focus on innovation: Implement a strategy that encourages innovation to remain competitive. This includes investing in new technologies, responding to environmental changes, and ensuring that innovation is a core part of the business model.

- Embrace digital marketing: Use digital tools to enhance your marketing efforts. Digital marketing offers opportunities for innovation in products and services and is crucial for staying competitive in a globalized market.

- Conduct regular market and consumer research: Regularly analyze market trends and changing consumer preferences to adapt business processes accordingly. This helps ensure that marketing activities and the company's offerings remain relevant and meet customer needs.

- Develop agile marketing plans: Modern marketing requires a flexible approach that can respond to both external economic conditions and internal company strengths. Avoid over-concentrating on short-term financial indicators, which can lead to long-term market loss.

- Integrate international marketing: Develop a specific international marketing strategy that is based on national marketing principles but tailored for foreign consumers. This helps in meeting the needs of foreign consumers by creating a competitive advantage in international markets.

Invest in personnel development: Improve internal management by investing in the skills of your employees, especially in marketing and innovation. This can be achieved through educational programs and training, helping to improve the overall management of foreign economic activity and competitiveness.

Benefits for enterprises:

- Increased competitiveness: Modern strategies lead to enhanced competitiveness, improved

market position, and a stronger brand image.

- Improved financial performance: By optimizing operations and focusing on profitability, modern marketing can directly contribute to revenue growth and increased profitability.

- Effective risk management: A strategic and adaptive marketing approach helps in managing risks associated with the changing market environment and economic conditions.

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THE MANAGER'S ROLE IN SUPPORTING THE PSYCHOLOGICAL WELL-BEING OF THE TEAM UNDER STRESSFUL CONDITIONS

Modern work life often involves stressful conditions. For Ukrainian companies, this is especially true during war, economic instability, and constant change. In this situation, the role of the manager is very important. It is not enough to just control tasks. A modern manager must care for the psychological well-being of the team to maintain productivity and a healthy atmosphere.

Stress can show itself in different ways: reduced motivation, conflicts between colleagues, fatigue, and lower quality of work. The manager is the first who can notice these signs and help the team. Good psychological well-being is not just a trend; it is a key factor for a company's success. A team that feels supported works better and is more loyal to the company.

There are several practical ways a manager can support the team. First, it is important to create open communication. Employees should feel safe to talk about their difficulties without fear of judgment. Regular, honest conversations help with this. Second, a manager must be flexible. Understanding that an employee may have personal problems or need a different work schedule helps build trust. For example, allowing flexible start times or short breaks during the day can significantly reduce stress.

Another important tool is showing appreciation. Simple "thank you" words or recognition of successes help employees feel valued. This is especially important during difficult times. Also, a manager should provide clear tasks and realistic deadlines. Uncertainty increases stress, while clarity helps the team feel confident.

It is also important to care for the team's microclimate. Organising online coffee breaks or team-building activities, even remotely, helps maintain connections between colleagues. This prevents people from feeling isolated. If possible, a manager can invite a psychologist for a group session or provide information about psychological support services.

However, the manager must also remember their own well-being. A tired and stressed leader cannot effectively help the team. Therefore, self-care and time for rest are also part of the manager's job.

In conclusion, in today's stressful conditions, a manager's role has expanded significantly. It is not just about achieving results but about creating a supportive environment where employees can work effectively despite external pressures. Managers who invest in the psychological well-being of their teams build stronger, more resilient, and more successful organizations. This is especially important for Ukraine, where supporting people is the key to overcoming challenges together.

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MAIN FUNCTIONS OF THE NATIONAL BANK OF UKRAINE

The National Bank of Ukraine (NBU) is the central bank and a special public authority responsible for ensuring the stability of the national economy. Its activities are aimed at maintaining price and financial stability, regulating the banking system, and creating favorable conditions for sustainable economic development. Acting as the architect of the financial ecosystem, the NBU plays a crucial role not only in monetary policy and financial supervision but also in strengthening Ukraine's integration into the global economy.

In the process of setting its strategic goals, the National Bank of Ukraine pays considerable attention to analyzing the external environment, as political, economic, social, and technological factors define the foundation for the country's economic and financial development. In its updated strategy, the NBU identified and took into account the key external factors that will significantly influence its activities in the near future.

The foremost element of the political context is Russia's full-scale war against Ukraine, which has continued for more than one thousand days. Despite the extreme uncertainty, the NBU has been successfully fulfilling its mandate while ensuring flexible planning and adapting to new challenges. Continuous diplomatic, military, and political support from NATO member states remains a crucial factor for Ukraine's victory and stabilization. At the same time, the volume of international financial inflows depends largely on Ukraine's progress in implementing structural reforms, as well as on political shifts in partner countries.

Another important aspect of the political context is Ukraine's EU accession negotiations. The country is gradually harmonizing its legislation with the EU acquis; however, the incomplete implementation of reforms still poses a significant obstacle to deeper integration into the European community and the attraction of large-scale investment. Therefore, in terms of domestic policy, Ukraine must continue pursuing structural reforms, fostering institutional development, and aligning its laws with European standards.

The future of Ukraine's economy is largely determined by the situation at the frontline, the scale of international cooperation, and the success of ongoing reforms. At the same time, there are significant risks related to the reduction or irregularity of international assistance flows, as well as challenges in financing domestic budget expenditures.

One of the key obstacles to economic recovery is the high level of the shadow economy, which includes financial institutions outside the NBU's regulation and companies engaged in unlicensed activities, particularly in the field of virtual assets. Additional constraints on recovery include weak domestic demand, a decline in the supply of goods and services, and serious limitations in export logistics. Under these conditions, the development of unsubsidized market lending in a competitive financial environment becomes particularly important. Expanding access to credit resources will stimulate entrepreneurship and support the revival of the country's economic dynamics.

When formulating its strategic goals, the National Bank of Ukraine takes into account a wide range of internal and external factors that shape both its strengths and its constraints. To conduct such an assessment, the NBU relies on SWOT analysis, which makes it possible to evaluate institutional advantages and weaknesses, as well as the challenges and risks arising from the external environment. This approach is especially relevant during wartime, as the central bank's effectiveness directly impacts the resilience of the national economy.

Among the strengths that enhance the NBU's position are the lessons learned from past crises and the institution's solid reputation among international partners. Its institutional independence and collegial decision-making process help maintain transparency and accountability, while continuous development of analytical capacity and the adoption of Fintech and Regtech innovations increase operational efficiency. The experience gained from working remotely during the pandemic and the war has proven the institution's adaptability, while its expertise in cybersecurity ensures the protection of the financial

system from digital threats.

At the same time, the NBU faces internal weaknesses that limit its potential. Political pressure and unrealistic public expectations often push the institution to act beyond its mandate. Internal bureaucracy and an underdeveloped corporate culture reduce the efficiency of operations, while the low financial literacy of the population remains a systemic issue. The weak development of the credit, insurance, and equity markets hinders the expansion of financial services. Furthermore, incomplete structural reforms, including judicial reform, along with insufficient protection of creditors' rights, create additional barriers. Finally, Ukraine's heavy reliance on external financial support increases vulnerability and poses risks to macroeconomic stability.

Therefore, the interplay of strengths and weaknesses defines the strategic directions for the NBU's future development and highlights the areas that require targeted improvements in order to enhance the effectiveness of the central bank.

In assessing the external environment, the National Bank of Ukraine has identified several key opportunities and threats that could significantly influence its strategic goals. Understanding these factors allows the NBU to strengthen its position and mitigate potential risks.

There are some main opportunities:

- Entry of new players into the banking and non-bank financial markets during economic recovery.
- Rapid post-war recovery and overall financial sector growth.
- Privatization of state-owned banks, which may attract private capital.
- Renewed private business interest in capital markets.
- Development of financial and security solutions based on blockchain technologies.
- High professional expertise of employees.
- Increased efficiency of the financial market through the integration of AI tools.

There are also some major threats:

- Growing share of state-owned banks in total financial assets.
- Deterioration in loan servicing quality.
- Significant pressure on the NBU's monetary mandate.
- Potential loss of the NBU's institutional independence.
- Rising debt burden on the economy.
- Expansion of state preferential lending programs, creating budgetary pressure.
- Intense competition for qualified staff and the risk of losing experts, including due to mobilization.
- Use of financial infrastructure for fraud or other illegal transactions.

To summarize, the National Bank of Ukraine plays a key role in ensuring the stability of the financial system and supporting the economy, especially under conditions of war and uncertainty. SWOT analysis allows the NBU to consider its strengths and weaknesses, as well as opportunities and threats, for effective strategic planning.

The Bank's strengths and technological innovations support efficient management of the financial sector, while internal weaknesses and external challenges require careful strategy. Opportunities, such as economic recovery and bank privatization, create conditions for growth, while threats highlight the need for vigilance. Through systematic analysis and an adaptive approach, the NBU is able to maintain financial stability and contribute to Ukraine's sustainable economic development.

SECTION 4. INFORMATION TECHNOLOGIES

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ADVANTAGES AND DISADVANTAGES OF THE ARTIFICIAL INTELLIGENCE IN PROGRAMMING

In the modern world of technology, artificial intelligence (AI) holds one of the leading positions in the development of programming and the IT industry. Thanks to the use of neural networks, the programming process becomes not only faster but also more efficient [0]. Today, AI helps programmers write, test, and optimize code, creating a new level of automation that allows most routine or repetitive tasks to be performed automatically without direct human interference.

Artificial intelligence can generate code fragments, suggest code modifications or bug fixes, and even create complete algorithms based on short task descriptions. For example, ChatGPT or Copilot can help a programmer quickly write a function or find the optimal solution to a given problem. This significantly reduces development time and allows developers to focus on writing more complex functions [0].

It should be underlined, that testing is one of the most important stages of programming. AI checks the code and detects bugs, vulnerabilities, and flaws within seconds. Moreover, a machine learning algorithm can analyze large amounts of data and select the most efficient execution ways. With the help of artificial intelligence it is possible to quickly visualize different usage scenarios of a program, which improves the quality of the final product and reduces debugging time.

However, despite its significant advantages, there are also drawbacks to consider. One of the most common is the reduction of a developer's independence. «If a programmer relies too heavily on neural network suggestions, they may lose the ability to independently analyze errors, find solutions, and improve their skills. Therefore, AI should not be viewed as a fully capable "developer" who can do all the work for the user, but rather as a "consultant" that can suggest or correct specific issues or errors. From this drawback arise others, such as the possibility of errors in generated code, security and privacy risks, copyright issues, and more» [0].

The conclusion is: despite the fact, that artificial intelligence has become an integral part of modern programming opening new opportunities for learning and creativity among developers, AI cannot completely replace humans, as it lacks creative thinking and deep contextual understanding. So the best approach is collaboration between humans and AI, where the human acts as «the main mind», and artificial intelligence complements and fixes problems that arise along the programmer's path.

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EXAMINING THE CHALLENGES IN AI'S FUTURE DEVELOPMENT

In the world of artificial intelligence, we are slowly approaching the edge. Moore's Law has ceased to keep pace with developments, resulting in a crisis of information scarcity. The core weakness

of today's AI architecture is its 'computational hunger'. Training and teaching large models requires thousands of GPUs/TPUs, which should be sufficient for a long time. But the computational costs of training advanced models are growing exponentially faster than hardware capabilities, outpacing even Moore's Law. Inference consumes a tremendous amount of resources so that people can use artificial intelligence for everyday purposes. In addition to the lack of data, there is also the issue of quality. We are forced to reduce the effectiveness of training by using contaminated data, which leads to biases and ultimately requires compensation.

Chen Z et al. propose a unique solution involving a profound change in the model that promises a breakthrough in optimisation [2]. The MoE architecture in its variant promises greater structural mobility. Instead of one giant model, it proposes creating a multitude of 'experts' – small sub-models that will respond to local and relevant queries. In this case, we have a total number of parameters of about a trillion, but we reduce the cost of inference to tens of billions of them [2].

The second approach focuses on process optimisation, aiming to maximise the efficiency of every bit of data and each computational operation.. Alzubaidi L. et al. insist on a paradigm shift from 'more data' to 'better data'. This involves careful filtering and deduplication of training data, the use of 'synthetic' data generated by artificial intelligence itself to fill in the gaps, and training based on 'Chain-of-Thought' and other more complex structures that teach more progressive 'thinking'. [1]

Some proposals suggest replacing 32-bit numbers with 16-bit or even 8-bit numbers for most calculations. This should speed up the calculation process and reduce memory requirements. Alternatively, learning rate schedules and efficient optimisers are proposed, but the effectiveness of such methods is much lower than that of others.

The pursuit of algorithmic and hardware efficiency provides three additional approaches.

Distillation – a model compression option, a technique where the 'teacher' model transfers its accumulated knowledge to the 'student' model. This allows less powerful models to be deployed on less powerful hardware, including edge devices.

Quantisation – the process of reducing the bit depth of the numbers representing weights after training. This radically reduces the size of the model and speeds up inference, while maintaining high performance.

Specialised hardware accelerators – chips designed specifically for AI inference rather than general-purpose computing.

In conclusion, we should use effective structures, high-quality data, and advanced optimisation algorithms, gradually shifting our focus to inference, since most of the main problems lie therein. Thus, sustainability is becoming a key factor and a mandatory requirement for the next generations of AI systems.

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ATTACKER ENTRY POINTS IN EMAIL PHISHING THREATS

Annotation. The attacker's methodology for exploiting email phishing threats was analyzed through the four critical entry points: the sender address, the message body, embedded URLs and attachments. It was detailed how each component is weaponized as a primary vector for initial compromise, credential harvesting, and payload delivery, confirming the integrated tactical approach of

modern phishing campaigns.

Keywords: phishing, electronic mail, cybersecurity, social engineering, attack methodology, exploitation tactics, initial compromise, threat realization, spear-phishing strategy, evasion techniques, payload delivery.

The modern threat landscape dictates that successful phishing campaigns must optimize resource exploitation. From the adversary's perspective, the electronic mail message is not merely a communication tool but a highly efficient attack platform composed of four exploitable entry points, each serving a specific tactical function to achieve initial compromise.

The first point of exploitation is the sender address, where the tactical goal is protocol evasion and trust establishment. The adversary exploits this field to feign legitimacy (sender spoofing) and bypass perimeter defenses. The attack is initiated by utilizing typosquatting – creating deceptive domain variations (e.g., substituting nbu@gov.nbu.ua for the legitimate domain @bank.gov.ua). Attackers also perform metadata forgery to bypass security checks, often by exploiting weak or misconfigured SPF/DKIM protocols.

The second core component is the textual content, which serves as the entry point for the social engineering attack. The strategy here is to manipulate the user's emotional state to force an immediate, uncritical response. Attackers employ linguistic constructs to create cognitive overload, using high-pressure urgency or fear ("Your account will be blocked, if you do not confirm your login credentials within 24 hours"). This ensures the target bypasses standard security protocol review before executing the payload.

The third entry point is the URL and hyperlink, the primary vector for credential harvesting and redirection. The goal is to funnel the target from a secure environment to a controlled attacker resource. The adversary employs link obfuscation to conceal the actual fraudulent hostname. The link directs the victim to a malicious server, often a phishing clone (e.g., https://signin-pyplsecurednotification.com/r/verifynow instead of the authentic https://www.paypal.com/signin), enabling the collection of sensitive authentication material.

Finally, attached files represent the most direct and potent vector for system compromise and payload execution. The attacker's strategy is to achieve full system compromise by embedding a malicious payload within seemingly benign file types. The attack is realized by naming the file to align with the social engineering narrative (e.g., "Invoice.zip"), ensuring the target willingly executes the final system infection payload. The embedded payload often utilizes dangerous dual extensions or types (e.g., *.exe, *.scr, *.pdf, *.doc, *.zip) which, upon opening, can activate embedded macros or executables to deploy malware.

Conclusions. The successful realization of a phishing attack is contingent upon the strategic, integrated exploitation of these four communication components. Each component is a necessary tactical entry point, confirming that effective defense requires developing countermeasures that target the adversary's methodology at every stage of the email delivery process.

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MASTERING THE ENGLISH LANGUAGE IN THE PROCESS OF STUDYING MODERN SOFTWARE DEVELOPMENT METHODS

Mastering the English language is becoming an integral part of the training of future IT specialists. In the modern world, software development relies heavily on English-language sources — technical documentation, APIs, libraries, scientific articles, and developer communities [1]. Therefore, effective acquisition of English in the context of IT education has an interdisciplinary nature: the language serves not only as a subject of study but also as a tool for professional growth.

A practical example includes studying Python syntax through official English-language documentation or using educational platforms such as freeCodeCamp and W3Schools, where all

materials are presented in English. During team projects, students may communicate in English via GitHub or Discord chats while discussing task distribution — this develops communicative skills and technical vocabulary.

It is advisable to combine learning professional English with studying modern programming technologies (Python, JavaScript, C++), development methodologies (Agile, Scrum, DevOps), and collaboration tools (GitHub, Jira, Trello). Such an approach helps students acquire practical skills in applying English-language materials under real software development conditions [2]. For instance, completing laboratory assignments with comments in English or preparing README files for personal projects reinforces both language proficiency and technical competence.

Effective teaching methods include project-based learning, collaborative tasks, and gamified platforms (Codecademy, Duolingo, Kahoot!) that promote independent student work. Special attention should be paid to the CLIL approach (Content and Language Integrated Learning), which integrates subject-specific content (programming, algorithms) with simultaneous language development [3]. This integration enables natural formation of professional terminology.

The key principles of organizing the learning process include: authenticity — working with real technical texts and documentation; communicativeness — participating in role-based situations such as code reviews or team meetings; practicality — creating personal mini-projects with English-language descriptions; interactivity — using online courses, Stack Overflow forums, GitHub Discussions, etc. [4].

For example, the instructor may ask students to create a simple website in English or conduct a project demonstration ("Project Demo") in English. Such assignments combine technical and language training and build confidence in intercultural communication.

Thus, learning English in the process of mastering modern software development methods fosters not only language competence but also critical thinking, intercultural communication skills, and professional mobility. This is an essential factor in preparing a competitive specialist in the IT sector.

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NUMERICAL ALGORITHM FOR DESIGNING A SPIRAL ANTENNA WITH VARIABLE POLARIZATION

Spiral antennas with adjustable polarization can produce RHCP, LHCP, or linear polarization by modifying the phase relationship between their feed ports. These antennas are widely used in satellite communication systems, GPS receivers, Wi-Fi networks, and various broadband wireless applications. To accurately predict how such structures behave electromagnetically, engineers rely on numerical simulation methods that allow realistic performance evaluation before fabrication.

The design process starts with defining the target operating band and overall frequency coverage. At the same time, the desired polarization type and the mechanism used to switch between modes are specified. Constraints such as allowable dimensions, material selection, and installation requirements are also considered. Key performance goals are set, including achieving S11 below −10 dB, an axial ratio under 3 dB, adequate radiation efficiency, and sufficient gain.

The choice of numerical technique depends on the antenna's geometry. FEM is typically used when the design contains dielectric layers or bulky conducting elements; MoM/NEC is more suitable for thin-wire models; and FDTD is selected for wideband analyses in the time domain. Based on these factors, appropriate simulation tools—such as HFSS, FEKO, or NEC—are chosen.

A detailed model is then built by defining the spiral diameter, inter-turn spacing, number of turns, and conductor profile. A ground plane or reflector may be included if the radiation pattern requires modification. Feed ports and transmission paths are configured to support polarization switching through controlled phase adjustments.

Before running simulations, a computational mesh is generated, usually with element sizes not exceeding λ/10 and refined to around λ/20 in areas of strong field gradients. Boundary conditions such as PML or equivalent open-space settings are placed sufficiently far from the structure. Excitation parameters and the phase shifts between ports are applied, along with optimization settings.

Initial simulation results provide essential data: S11, input impedance, three-dimensional radiation characteristics, gain values, and axial ratio across the operating band. These metrics are examined to evaluate matching performance, polarization purity, radiation behavior, and overall efficiency.

Afterward, the optimization phase begins. An objective function is formulated to minimize both S11 and AR while preserving or increasing gain. Tunable variables may include the size of the spiral, turn spacing, conductor thickness, reflector spacing, and the phase configuration of the feeding network. Optimization continues until the antenna satisfies all performance requirements with stable results.

Once the optimized model is ready, its manufacturability is assessed. A realistic feeding network is incorporated, and a prototype antenna is produced. Measurements of S11, axial ratio, and radiation patterns are taken and compared with simulated predictions. If discrepancies appear, the model is updated and refined accordingly.

The final stage involves preparing complete technical documentation, including manufacturing drawings, material specifications, and assembly and phase-control guidelines. This ensures the antenna can be reproduced accurately with consistent performance characteristics.

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THE IMPORTANCE OF MODERN IT IN SHAPING THE SOCIETY OF THE FUTURE

In the modern world, digital technologies play a key role in the development of society, economy and culture. They have become an integral part of human everyday life, penetrating into all areas of activity - from education and medicine to business, science and public administration. Due to digital technologies, we are able to quickly receive, process and transmit huge amounts of data, which significantly increases work efficiency, facilitates communication and promotes globalization.

The current stage of IT development is characterized by the active implementation of innovative

areas, such as artificial intelligence, machine learning, cloud technologies, Internet of Things, blockchain and cybersecurity. These technologies are fundamentally changing approaches to information management, automation of production processes and decision-making. For example, artificial intelligence allows you to create intelligent systems that can analyze large data sets and learn independently, and cloud services provide convenient access to resources from anywhere in the world.

Digital technologies have become a powerful engine of economic development. They contribute to the digital transformation of enterprises, optimization of business processes and expansion of the service market. E-commerce, online payments, customer relationship management systems and remote work are all consequences of the impact of IT on modern business. Application of the latest technologies allows companies to increase competitiveness, reduce costs and adapt to consumer needs.

Digital technologies also play an important role in education and science. Thanks to digital platforms, interactive tools and distance learning systems, the educational process becomes more accessible and flexible. Use of virtual laboratories, multimedia tools and artificial intelligence in education contributes to the individualization of learning, development of critical thinking and creativity of students. In the scientific field, IT opens up new opportunities for modeling complex processes, data storage and international cooperation.

Along with the positive impact, development of IT is accompanied by certain challenges. Among them are the problems of cybersecurity, protection of personal data, ethical use of artificial intelligence and the risk of digital inequality. In this context, it is extremely important to form a digital culture, develop information literacy and ensure a responsible attitude to technology. The future of digital technologies looks extremely promising. They will continue to develop in the direction of creating "smart" cities, automated production, sustainable energy consumption and improving the quality of life of people. Digital technologies are not only a tool for improving modernity, but also the foundation for building an innovative, fair and environmentally safe future.

Thus, information technologies have become not only a means of development, but also a symbol of a new era in which knowledge, innovations and the progress of information determine the success of the individual and the state. They open up boundless prospects for humanity - from the creation of artificial intelligence to the exploration of space, from distance learning to electronic democracy. It is a balanced attitude to technology that will guarantee that the future we are building today will be reliable, harmonious and truly progressive.

In the ensuing decades, the combination of IT into all facets of human endeavour will only deepen, reshaping the manner people work, acquire knowledge, and engage. The progress of digital principles, openness, and worldwide collaboration will be vital to guaranteeing that technology benefits humankind as a complete.

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SMART TECHNOLOGIES FOR ENVIRONMENTAL PROTECTION

In the modern world, environmental safety has become one of the main priorities of social development. Smart technologies help to reduce the negative impact of human activity on nature by ensuring efficient resource management and environmental monitoring.
The use of sensor systems, drones, satellite technologies, and artificial intelligence makes it possible to track the level of air, water, and soil pollution as well as to predict environmental risks. The Internet of Things (IoT) enables the creation of "smart cities," where automated systems control energy and water consumption and manage waste disposal.

Such technologies form the foundation of sustainable development, combining innovation with responsible environmental behavior. The implementation of smart ecological solutions contributes to the preservation of natural resources and the improvement of the quality of life for future generations.

Smart technologies are transforming the way we approach sustainable development, offering innovative solutions to climate change, resource conservation, and pollution control. From smart grids and AI-

driven energy managemen to IoT-based waste tracking and precision agriculture, these technologies play a crucial role in creating a balance between economic growth and environmental protection.

To achieve true sustainability, governments, businesses, and individuals must work together to accelerate the adoption of smart technologies, ensuring a greener and more resilient future for generations to come.

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METHOD FOR SYNTHESIZING AN INFORMATION AND SECURITY EVENTS MANAGEMENT SYSTEM FOR A CORPORATE COMMUNICATION MOBILE NETWORK

The paper considers a method for synthesizing an information and security events management system for a corporate mobile network, aimed at improving the efficiency and adaptability of incident detection, analysis, and response processes in a dynamic, spatially distributed telecommunications infrastructure. The relevance of the issue is due to the complexity of the topology of modern corporate networks, the widespread use of mobile access (4G/5G, Wi-Fi 6E, SD-WAN), and the increasing intensity of security events, which cannot be handled by traditional SIEM solutions.

Based on the analysis, it was found that most existing security events management systems are limited by static architecture and do not sufficiently take into account node mobility, network state variability, and temporal correlation between events. This leads to reduced accuracy in incident classification and correlation, increased threat localization time, and reduced system resilience to abnormal traffic changes.

The proposed synthesis method is based on a logical-dynamic model that formalizes the interaction of sets of events, states, and control influences. The model provides the ability to describe the behavior of the system under changing topology conditions, and also allows building the decision-making process as a sequence of transitions between the dynamic states of the network and security subsystems. This approach provides adaptability and context-dependent response to threats.

An important element of the method is a digital twin of the security events management system, which performs modeling, simulation, forecasting, and decision verification functions in near real time. The digital twin integrates telemetry streams, analytical algorithms, and response mechanisms, creating a unified environment for testing hypotheses, predicting the consequences of incidents, and optimizing control actions.

To process a large array of events, the method uses machine learning algorithms, including support vector machines (SVM), decision trees, and recurrent neural networks such as LSTM. The use of these algorithms allows for increased accuracy in filtering noise events, distinguishing abnormal conditions, building behavior models, and performing temporal correlation of events in variable observation windows.

So, the developed method of synthesizing an information and security event management system provides a new approach to building adaptive, scalable, and predictive solutions for mobile corporate networks. The presented concept can be used to modernize existing SIEM/SOAR platforms, increase the level of response automation, and strengthen the protection of departmental and corporate information and communication systems.

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FEATURES OF BUILDING A KUBERNETES CLUSTER CYBER RESILIENCE MODEL USING SERVICE MESH (ISTIO) FOR CORPORATE NETWORK TRAFFIC MANAGEMENT

This thesis presents and analyzes an approach to creating a cyber resilience model for corporate networks using Kubernetes clusters. The main focus is on the capabilities of Istio Service Mesh. A structural model of cyber resilience is proposed, based on declarative network traffic management using Istio resources.

Modern corporate networks built on microservice architecture and containerization are becoming increasingly complex, requiring a rethink of approaches to network security and resilience. Traditional perimeter defenses have proven ineffective for controlling horizontal traffic within a cluster. The reliable operation of such systems critically depends on their ability not only to prevent cyberattacks, but also to withstand them and recover quickly. This highlights the need to develop a scientifically sound methodology for building a Kubernetes cluster cyber resilience model, leveraging the architectural advantages of Service Mesh for centralized security management.

The features of Istio that were taken into account when building the model are as follows:

Istio automatically implements mutual TLS (mTLS) for communication encryption, providing each service with a reliable identity. This forms the basis of the Zero Trust architecture.

Fault tolerance management: Istio's functionality actively increases the system's resistance to attacks and failures. In particular, the implementation of circuit breakers isolates overloaded or malfunctioning services, preventing cascading failures. Timeout control and flexible management of retries are also important.

The methodology for building a cyber resilience model based on Istio involves four key steps:

Step 1: Threat Identification and Analysis. Conducting a threat analysis and determining the criticality of their destructive impact on the corporate network.

Step 2: Implementing Protection Mechanisms. Configuring mTLS and creating and implementing access policies.

Step 3: Implementing Traffic Recovery Mechanisms. Configuring Virtual Service resources to set up timeouts and retry requests.

Step 4: Monitoring, Validation, and Auditing. Use Istio Observability features and automated tests to confirm the effectiveness of the developed security and functional resilience model.

The implementation of Istio Service Mesh in the Kubernetes cluster allows achieving a new level of structural cyber resilience of the corporate network. Further research will focus on quantitatively assessing the improvement in cyber resilience metrics after implementing the model and developing tools for automated auditing of Istio configurations for compliance with cybersecurity requirements.

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ARTIFICIAL INTELLIGENCE: POSSIBILITIES AND ETHICAL LIMITATIONS

Artificial intelligence is becoming an integral part of modern life, changing the way people learn, work and communicate. AI can automate routine tasks, analyze large amounts of information and provide personalized advice, helping users plan their time more effectively, organize their workday, make decisions, and increase productivity. In the learning process and professional activities, intelligent systems stimulate interest in learning and self-development, track progress, maintain motivation, and help control emotional state, creating a sense of security when performing complex tasks. AI can not only optimize work and learning, but also positively influence the user's psychological state, supporting activity and the development of independent decision-making skills within a controlled environment.

At the same time, constant interaction with AI also has psychological risks. Excessive trust in the system or dependence on automated advice can reduce independent thinking, lower concentration and decrease interest in performing tasks without the help of technology. Information overload, constant interaction with digital platforms and expectations of rapid feedback can cause fatigue, anxiety, emotional exhaustion, and decreased motivation. These factors are particularly important in education and professional training, where independence and readiness to take responsibility, and consequently responsibility for decisions made, are critical.

AI also affects the social aspects of behavior. The use of digital assistants, chatbots and communication automation can reduce the number of "live" social contacts and limit the development of empathy and social interaction. Individuals may become accustomed to relying on technology to resolve social issues, which over time reduces their ability to communicate effectively in society (in a group) and affects their psychological and social well-being.

For the safe and effective use of artificial intelligence, it is important to develop a conscious culture of interaction with technology. Users should: not only understand the processes in which they operate; understand the possible risks and limitations of AI; critically evaluate the advice and results of systems; and be aware of their own responsibility for the decisions they make. It is important to implement digital hygiene rules, including controlling the time spent interacting with technologies, limiting excessive use of devices, and avoiding information overload.

To maintain inner moral state and mental health, it is necessary to: take regular breaks; maintain social contacts, giving preference to live communication; practice conscious self-reflection and emotional regulation. Such approaches promote balanced interaction between humans and AI, reduce the risk of stress and emotional exhaustion, and help maintain motivation, attention, and active participation in professional activities, as well as promote self-development and self-improvement. In addition, it is important to develop skills for responsible use of technology, including critical thinking, assessing the reliability of information sources, and the ability to make your own decisions and take responsibility for them, without transferring that responsibility (consciously or subconsciously) to AI in automated support languages.

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THEORETICAL BASIS FOR IMPROVING THE ISOLATION FOREST ALGORITHM FOR ANOMALY DETECTION

This paper reviews theoretical methods for improving IF, focusing on:

1. Reducing the expected isolation path length for anomalies.
2. Minimizing variance of path length estimates to increase stability and reproducibility.
3. Preserving the computational efficiency and scalability of the algorithm.
4. Enhancing performance in high-dimensional, sparse, and noisy datasets.

Methods. Several theoretically grounded modifications are considered:

Random Hyperplanes and Directed-Random Splits.

Replacing univariate splits with random hyperplanes increases the probability of isolating rare points early, particularly in high-dimensional spaces. Directed-random split selection uses isolation gain to bias splits toward efficient separation while preserving randomness. This combination ensures that anomalies are isolated faster without sacrificing the diversity essential to ensemble robustness.

Controlled Subsampling of Observations and Features.

Subsampling ψ observations per tree stabilizes estimates by reducing correlation between trees. Random feature subsets at the node or tree level further improve diversity. Smaller ψ values enhance local isolation, while larger ψ improves stability. Selecting features differently per node versus per tree balances ensemble diversity and reduces structural degeneration. Subspace-Based Tree Construction.

High-dimensional data often contain irrelevant or correlated features. Building trees in separate feature subspaces mitigates noise and focuses splits on informative dimensions.

Conclusions.Improving Isolation Forest with random hyperplanes, directed-random splits, controlled subsampling, subspace tree construction, and regularization increases detection accuracy and stability in high-dimensional, sparse, and variable datasets. These modifications reduce the expected isolation path length and its variance, enhance reproducibility, and preserve computational efficiency, providing a robust theoretical framework for modern anomaly detection applications.

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PROSPECTS FOR IMPLEMENTING ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN THE ELECTRONIC COMMUNICATIONS INDUSTRY

The rapid development of artificial intelligence technologies opens up new opportunities for qualitative improvement of electronic communications systems, which currently operate in a highly dynamic environment with constantly growing loads. Modern communication networks combine multi-level architectures, heterogeneous technologies and a large number of interacting elements, which complicates their management using traditional methods. In such conditions, the use of AI becomes a key tool for improving the efficiency, stability and adaptability of telecommunications systems. Intelligent models provide real-time analysis of the network situation, more accurate traffic forecasting and optimisation of resource allocation, which increases fault tolerance and reduces the likelihood of overloads and downtime.

The application of AI in network management includes equipment configuration automation, routing optimisation, load balancing, and failure detection before the user notices them. Machine learning algorithms allow the network to adapt to changing conditions, including reacting to sudden

traffic spikes or changes in the availability of individual nodes. Intelligent systems support the concept of self-organising networks (SON), which is particularly important for future generations of communications, where autonomy and real-time controllability are critical parameters.

Another important area is the integration of AI into the field of electronic communications cybersecurity. The growing complexity of cyber threats and their transition to automated forms requires a similar level of intelligence from security measures. AI-based systems are capable of identifying traffic anomalies, analysing behavioural patterns, recognising deviations from normal network activity, and blocking potentially dangerous operations in real time. This increases the cyber resilience of infrastructure and enables a proactive rather than reactive approach to protection.

At the same time, the widespread implementation of AI comes with a number of challenges. Among them is the need for access to high-quality data for training models, which is a critical factor in the success of intelligent systems. Along with this, there are questions about the security of the AI models themselves, which can be subject to manipulation or adversarial attacks. The ethical aspect of using AI in critical areas is also significant: some decisions must remain under human control, and automation should not lead to opaque decision-making or a reduction in accountability.

The prospects for development lie in the formation of AI-driven networks — a new generation of intelligent networks capable of functioning with a high degree of autonomy and making decisions based on the analysis of large amounts of data in real time. Such networks will provide self-configuration, adapting operating parameters depending on changes in traffic or the state of network resources, as well as self-healing, which involves automatic detection of the causes of failures and selection of optimal ways to restore functionality without human intervention. An important component is predictive planning, where the system identifies potential overloads, threats or service degradation in advance and takes preventive measures. It’s the integration of AI with virtualised and software-defined architectures that will determine the future direction of electronic communications in the coming decade.

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PARAMETER-EFFICIENT FINE-TUNING (PEFT) METHODS FOR LARGE LANGUAGE MODELS: A COMPARATIVE ANALYSIS

The rapid advancement of Large Language Models (LLMs) has demonstrated their immense potential across various domains, yet their effective deployment often requires task-specific fine-tuning. Full fine-tuning is computationally demanding and resource-intensive, making it prohibitive for most practitioners and organizations. Parameter-Efficient Fine-Tuning (PEFT) methods, such as LoRA (Low-Rank Adaptation) and Prefix-Tuning, have emerged as crucial techniques to mitigate these challenges by updating only a small subset of model parameters while achieving performance comparable to full fine-tuning. This research aims to provide a comparative analysis of the most prominent PEFT methodologies, specifically evaluating their performance metrics, computational overhead, and memory efficiency across different downstream natural language processing (NLP) tasks.

The study focuses on three key aspects: first, the theoretical underpinnings of selected PEFT methods, detailing how each technique modifies the model's architecture or training process to enhance efficiency. Second, an empirical evaluation is conducted using a consistent baseline LLM (e.g., Llama 2) and a set of diverse tasks, including summarization, question answering, and sentiment analysis. Performance is measured by task-specific metrics (e.g., ROUGE, F1-score). Third, a crucial comparison

of training time, required GPU memory, and the size of the checkpoint files is performed to quantify the practical benefits of each PEFT method. Preliminary results suggest that LoRA generally offers a superior trade-off between performance preservation and parameter reduction, making it highly suitable for resource-constrained environments. However, other methods may show advantages in specific, highly specialized tasks. The findings will provide practical guidance for researchers and developers on selecting the optimal PEFT strategy based on available hardware, computational budget, and target application requirements.

Conclusion: the efficient fine-tuning of LLMs through PEFT methods is indispensable for democratizing access to and leveraging state-of-the-art models in real-world applications. By quantifying the performance, speed, and memory trade-offs, this comparative study serves as a critical resource for informed decision-making in the field of large-scale AI deployment. Future work will extend this analysis to emerging PEFT variants and explore their efficacy in multi-modal and low-resource language settings, further contributing to the development of sustainable and scalable LLM ecosystems.

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IMPACT OF REDUCING THE TECHNICAL PROCESS IN THE CPU ON EVERYDAY LIFE

The size of the CPU process nodes has significantly decreased over the past few decades. One of the first CPU from Intel, “Intel 4004” from 1971, used the 10 000 nm process with 2300 transistors. By the 1990s, Intel Pentium had had 300 nm. The 2010s Intel introduces 14 nm (Broadwell) and AMD 7 nm (Zen 2). In 2025, 3 nm (TSMC N3, Apple M5) chips are in production, containing over 50 billion transistors in high-end configurations. This evolution relies on advanced lithography and materials.

Smaller technical process allows for greater productivity or lower energy consumption. A 3 nm transistor requires up to 40% less energy than a 10 nm one at the same productivity level. This reduces heat and allows higher performance without increased energy consumption.

Also, the battery life of portable devices is much longer now. For example, a 10-year-old laptop with 14 nm Intel Skylake lasted 6-8 hours under office workload while more modern solutions based on Intel Lunarlake (3 nm-class) offer 16–18 hours using a similar 55–60 Wh battery.

Lowering technical process enables entirely new devices and advanced features. Wireless earbuds now perform adaptive active noise cancellation and real-time language translation locally, Smart glasses integrate full-color augmented reality displays with eye-tracking and gesture recognition, fitness rings continuously monitor heart rate variability, stress, and sleep stages with a week of battery life.

The required level of performance and battery life for everyday academic and office tasks was already achieved in devices built on 10–14 nm nodes several years ago. Laptops and tablets with 10–14 nm processes have been easily handling everyday tasks of students and office workers. Today, even the simplest models, such as $200 – $350 Intel N100 (6 nm) or MediaTek MT8188 (6 nm), offer from 10 to 12 hours of battery life, smooth internet browsing, video calls and document editing. This is sufficient for 95% of educational and work needs. Previously, such characteristics were only available in the mid-price segment, but thanks to the scale of production and the reduction in the cost of components, such devices have become affordable. For comparison: in 2010, a 45 nm laptop cost $400, but it only worked for 4 hours and slowed down while multitasking. Today's budget devices with 6-10 nm CPUs are a reliable choice for students and remote office workers. Now they do not need top-of-the-line specs to be effective.

All of this is the result of Moore's Law, formulated by Gordon Moore in 1965: the number of transistors on a chip doubles every two years leading to increased performance and lower costs. Although physical limitations (such as quantum tunnelling below 2 nm) are slowing down traditional scaling, the future promises to be exciting. New technologies such as gate-on-insulator transistors, 3D chips and specialized architectures will continue to improve efficiency.

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USE OF SIEM SYSTEMS FOR AUTOMATING INFORMATION SECURITY INCIDENT MONITORING

In the modern digital landscape, the intensity and sophistication of cyberattacks are growing exponentially. Organizations of all sizes face threats ranging from ransomware to advanced persistent threats (APTs). Traditional methods of manual log analysis are no longer effective due to the vast amount of heterogeneous data generated by network devices, servers, and applications. Consequently, the implementation of Security Information and Event Management (SIEM) systems has become a mandatory requirement for ensuring cyber resilience. These systems facilitate the transition from reactive to proactive defense strategies by automating collection, normalization, analysis, and correlation of security events in real-time. The primary objective of this research is to analyze the efficiency of deploying open-source SIEM solutions, especially the Wazuh platform, to automate incident detection and response within a corporate network simulation. The study focuses on achieving three specific goals: 1) configuring a centralized log management system for a hybrid environment (Linux and Windows); 2) evaluating the system capability to detect specific attack vectors, such as brute-force attempts and unauthorized system modifications; 3) demonstrating the automated mitigation of threats using active response mechanisms to reduce the Mean Time to Respond (MTTR). The research methodology involved the creation of a virtualized laboratory environment using VMware Workstation. The infrastructure comprised a central server running Wazuh Manager (version 4.7) deployed on the Ubuntu 22.04 LTS operating system. The monitoring perimeter included client agents installed on virtual machines running Windows 10 Enterprise and Windows Server 2019. The configuration process included fine-tuning the `ossec.conf` file to enable key modules: File Integrity Monitoring (FIM) for tracking changes in system directories, and Security Configuration Assessment (SCA) for compliance checking. To simulate security incidents, the Kali Linux distribution was used as an attacker machine. Specifically, the Hydra tool was employed to perform SSH and RDP brute-force attacks, while custom scripts were executed to modify registry keys on the Windows targets, simulating malware persistence mechanisms.

The experimental deployment demonstrated that the Wazuh platform successfully integrates with the Ubuntu host and establishes stable, encrypted communication with Windows agents. During the stress testing phase, the SIEM system effectively aggregated logs and triggered high-severity alerts. For the brute-force simulation, the system correlated multiple "Authentication Failure" events (Windows Event ID 4625) into a single high-priority alert (Rule ID 5712). The File Integrity Monitoring module successfully detected unauthorized changes to the Windows Registry and critical system files in real-time, providing detailed metadata about the user account responsible for the modification. Crucially, the configuration of the Active Response module proved effective. Upon detecting a brute-force attack from a specific IP address, the system automatically executed a `firewall-drop` script. This action updated the `iptables` rules on the Linux server and the Windows Firewall policies on the agents, banning the attacker's IP address for 600 seconds. This automation confirmed the system's ability to block threats without human intervention.

The study confirms that deploying a SIEM system is a critical component of a robust

cybersecurity architecture. The research showed that open-source solutions like Wazuh provide enterprise-level capabilities for log analysis, threat detection, and automated response without the prohibitive costs associated with proprietary software. Implementation of such systems allows organizations to significantly improve their security posture, ensure compliance with regulatory standards, and reduce the workload on security analysts. Future research will focus on integrating the SIEM with external Threat Intelligence feeds and exploring machine learning capabilities for anomaly detection.

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THE MODERN IT SECTOR IN UKRAINE: CURRENT STATUS, PROBLEMS AND POSSIBLE PROSPECTS FOR DEVELOPMENT

The modern development of IT has the potential to fundamentally change people's lives – their work, leisure, ways of forming communities, and even their attitude towards themselves. The most significant influence is that of the Internet. The global network has provided opportunities for the creation of a completely new segment of online start-ups, which have entered the global market with almost three billion Internet users thanks to low implementation costs. The largest of these start-ups, Google and Facebook, are now the world's leading IT companies.

Today, the IT sector is one of the most dynamic segments of Ukraine's economy, which is actively developing. However, despite significant growth, the Ukrainian IT market remains small by global standards, accounting for about 1% of the global total.

Over the past few years, a large number of IT specialists, or one-tenth of their total number, have left the country to work abroad. This is due to the low standard of living in the country, political instability, and the lack of legal protection for businesses from pressure from state bodies and law enforcement agencies, especially during the war.

The modern IT sector in Ukraine faces challenges such as a shortage of skilled personnel, insufficient funding, and cyber threats, but it has significant prospects for development thanks to the export of services, government support, the development of innovative technologies, and adaptation to global trends. Prospects include further improvement of IT services, enhanced cooperation and globalization, as well as the introduction of cutting-edge solutions such as artificial intelligence, cloud technologies and blockchain.

Thanks to the high level of qualification of Ukrainian IT specialists, the industry remains competitive in the global market. According to data from specialised analytical centres, Ukraine is among the top 20 countries in Europe in terms of technological potential.

The main trends in development include growing demand for software development, particularly in the fields of fintech, cybersecurity, e-commerce, and military tech; increased startup activity and a growing share of product companies; expansion of digital government services (Дія, eHealth, e-registries); strengthening of national cyber defence and development of technologies for the defence sector; support for the IT ecosystem through tax models (Дія City).

We can assess the industry's potential in the medium and long term as high. The expected areas of innovative growth are Military Tech — the development of defence digital solutions, UAVs, and artificial intelligence systems for the Armed Forces of Ukraine; cybersecurity and digital sovereignty; development of state digital services and Smart Governance; artificial intelligence, Big Data, robotisation of production processes; IT education programmes — expansion of specialist training in higher education institutions and integration into European technology markets, support for the start-up ecosystem.

The further development of IT depends on effective government policy, business protection, infrastructure modernisation, and the creation of competitive conditions for specialists.

The Ukrainian IT sector remains one of the key elements of the national economy and defence capability. Despite the challenges of wartime, it demonstrates resilience, technological innovation and

significant potential for post-war recovery. The development of the industry should be based on expanding investment, supporting start-ups, digitising the state, and integrating into global markets. Provided that systemic reforms are implemented, IT could become one of the key drivers of Ukraine's economic growth in the coming decades.

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FACILITATING EQUITABLE ACCESS TO GLOBAL DIGITAL INFRASTRUCTURE

One of the most significant themes in the 21st century is the growing influence of digital infrastructure worldwide. Accessibility for everyone has never been more important than it is now as paperless technologies are used in all aspects of daily life. The rapid digitization of everything has caused a problem known as the digital divide, it is an issue which splits individuals into those who have reliable access to the internet and those who don't have any access to it at all. Promotion of equitable access is crucial for ensuring development, social integration, and economic prosperity for everyone.

The digital divide manifests itself through many factors such as geographical differences, economic barriers, the state of infrastructure and low levels of digital literacy. According to recent World Bank data, approximately 32% of people globally remain offline, with the most significant gaps concentrated in rural areas and marginalized communities [1]. This limits opportunities for education, employment and access to health care resulting in inequality. On the other hand, regions that improve their digital coverage experience economic growth, improved public services, and better quality of life.

A multilateral approach is necessary to solve the digital divide problem, this involves big investments and political cooperation. In regions without digital infrastructure, significant financial resources and strategic planning are required. Governments should prioritize constructing reliable internet connections to reach remote populations who desire to join the global network. For example, one of solutions could be using new satellites technologies, such as low Earth orbit (LEO) ones which will help provide high-speed internet to any location [2].

However, even in countries where digital infrastructure already exists, the cost of these solutions can still pose a significant issue. This problem can be solved by providing affordable pricing models for groups or communities and establishing good-quality public Wi-Fi hubs in locations such as schools, universities or social facilities. Tax reductions for building and making investments in digital infrastructure profitable may be motivating enough for private companies and individuals to help in IT expansion.

The development of using the internet is crucial too, as infrastructure alone cannot help people if they lack knowledge how to use it. It is necessary to implement various educational programs in schools and universities as well as adding additional courses for working people. All these efforts must be adapted to groups with diverse people allowing them all to fully participate in the internet network. Public spaces cannot be overestimated as they contribute to the growth of inclusive infrastructure. Society can bring big opportunities such as creating smart cities, municipal networks and digital public infrastructure. This will benefit all citizens by integrating them into national resources and offering secure data exchange, interoperable payments, and smart governance in apps.

In conclusion, providing equal access to digital infrastructure for all people requires cooperation. To achieve this, it is necessary to develop physical infrastructure that addresses cost, digital literacy and inclusive policy frameworks. Digital gap is a problem that can be solved and, when successfully handled, can lead to a new era. Making sure that no one is left behind must be a top priority for developing this type of initiative.

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THE IMPACT OF ARTIFICIAL INTELLIGENCE ON SOFTWARE DEVELOPMENT

Today, artificial intelligence (AI) is involved in almost every aspect of our lives. It is widely used as a search engine, means of automation or idea generation techniques. It influences most fields, especially software engineering. According to the Stack Overflow survey, 67% of software engineers use AI coding assistants, and 13% are planning to use them soon [1]. Quite apart from the obvious benefits, current tools have certain downsides.

When it comes to AI, we often refer to Large Language Models (LLMs), deep learning models trained on immense amounts of data, making them capable of understanding and generating natural language and other types of content to perform a wide range of tasks. These models struggle to hold large contexts, therefore, they cannot find the best solution. Computer scientists with Model Evaluation & Threat Research (METR), a non-profit research group, have published a study showing that AI coding tools made software developers slower, despite expectations to the contrary. «After completing the study, developers estimate that allowing AI reduced completion time by 20 percent,» the study says. «Surprisingly, we find that allowing AI actually increases completion time by 19 percent — AI tooling slowed developers down» [2]. That's because they spend much time explaining the LLM what must be done and correct its responses instead of actually doing their work.

Under these conditions the issue can be solved by loading an entire codebase into the model, but the problem is that not many companies would like to share their intellectual property with third-party vendors. An alternative way is to move on from general-purpose LLMs to domain-specific ones. If a company can afford to train a local model on its source code, the model will be aware of all the styles and the structural components. Therefore, it must represent more accurate solutions.

Another problem is code security and general bad practices. Research by Veracode reports that «in 45% of the tasks the models introduce a known security flaw into the code» [3]. Although the numbers may vary in different models, the core issue is that most models are trained on old data, and it takes a long time to retrain. In the reality, the vulnerabilities should be fixed as soon as they are identified.

While AI can assist with or automate more routine tasks, software engineering is far more than writing code. Engineers are also responsible for designing system architecture and decomposing large concepts into manageable tasks. These processes require a higher level of understanding, communication skills, teamwork, and creative thinking. AI tools can improve the software development process when used properly, but they will not replace actual developers.

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DETERMINING THE OPTIMAL ROUTE IN A COMPUTER NETWORK USING NEURAL NETWORK TECHNOLOGY

The relevance of this topic is substantiated by the rapid increase in service and user traffic within modern computer networks, particularly in railway transport systems. These networks have strict requirements for latency and demand adaptive, real-time routing. Traditional routing algorithms, such as Dijkstra and Bellman-Ford, are often inefficient in dynamic environments with changing loads, as they do not account for the dynamic nature of traffic. Intelligent tools, especially neuro-fuzzy networks, are promising as they combine the ability to learn from data with the capability to describe imprecise route quality criteria [1].

The objective of this qualification thesis is to determine the optimal route in a computer network using neural network technology. To achieve this goal, a review of scientific sources on neural networks suitable for routing tasks was conducted, including the Multilayer Perceptron (MLP), Hopfield network, Boltzmann machine, Radial Basis Function (RBF) networks, and the Adaptive-Network-based Fuzzy Inference System (ANFIS) . The ANFIS model, originally proposed by J.-S.R. Jang, was selected as the primary method [2]. ANFIS is advantageous as it integrates fuzzy "IF-THEN" rules with the adaptive learning mechanisms of neural networks.

A neuro-fuzzy network was created using the ANFIS mode of the Fuzzy Logic Toolbox in the MATLAB environment. The network was designed with a "12-24-144-144-1" configuration. This structure includes 12 input neurons (representing the delays on individual routers) , 24 neurons in the first hidden layer (two terms for each input) , 144 neurons in the fuzzy rule layer , and 1 output neuron that predicts the total route delay [3]. The model was trained to determine the optimal route based on the criterion of minimizing the total delay of the routers composing the route.

The study investigated the model's average error across different membership functions and optimization methods. The optimal parameters were identified: the Gaussian membership function combined with the hybrid optimization method [3]. This configuration achieved the lowest average error (RMSE) of 0.13 μs during training on a sample of 144 examples, stabilizing after 144 epochs . The model's practical accuracy was validated on 10 independent control scenarios. The analysis demonstrated that the ANFIS model correctly identified the optimal route (as determined by the Dijkstra algorithm) in 80% of cases. These results confirm the effectiveness of the neuro-fuzzy approach for adaptive traffic management.

The achieved 80% accuracy on independent control scenarios demonstrates a high level of practical applicability for the developed model. These findings confirm that the neuro-fuzzy approach is a viable solution for dynamic routing, particularly in complex environments like railway transport networks which must adapt to fluctuating traffic loads in real-time. The results strongly suggest the feasibility of integrating this ANFIS-based technology into actual network protocols. Doing so would allow the network to react more effectively to changes in load and potential node failures, thereby enhancing adaptive traffic management and improving overall network resilience and efficiency.

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BLOCKCHAIN TECHNOLOGY FOR DATA PROTECTION IN EDUCATION AND HEALTHCARE

In today's digital world, information has become one of the most valuable resources. Every day, millions of people rely on online systems to study, work, and communicate. Universities and healthcare institutions collect and store large volumes of sensitive data, including academic records, diplomas, and medical histories. However, modern technologies also bring numerous risks. Data leaks, cyberattacks, and identity theft have become serious global problems. As a result, many users lack trust in digital platforms and are reluctant to share their personal information.

The main issue is that traditional databases can be relatively easy to hack or manipulate. If unauthorized individuals gain access, they can copy, alter, or delete sensitive information. For example, falsified diplomas and fake certificates can appear online. In the healthcare sector, data manipulation can lead to even more dangerous consequences, as it may directly affect patient treatment. Therefore, new and reliable solutions are needed to ensure that data storage becomes more secure and transparent.

One of the most promising technologies addressing these challenges is blockchain. Blockchain is a decentralized digital system where information is divided into small blocks linked together in a chain. Each block contains data and a timestamp. Once recorded, a block cannot be changed or removed without leaving a trace. This makes blockchain systems highly secure and transparent. In addition, because blockchain does not rely on a single central server, it becomes much harder for hackers to launch successful attacks. Information is stored across many computers simultaneously, so even if one device is compromised, the data remains protected.

In the field of education, blockchain can be used to store diplomas, transcripts, and certificates. Each document can have a unique digital signature that verifies its authenticity. This prevents forgery and supports trust between universities and employers. Students can also store their achievements in digital wallets and share them when applying for jobs or scholarships. In healthcare, blockchain can protect patients' personal data and ensure secure information exchange between hospitals and medical professionals. Patients can control who has access to their medical records, increasing both privacy and autonomy. Furthermore, blockchain can help prevent data loss when patients move between hospitals or even relocate to another country.

Despite its advantages, blockchain still faces several challenges. The technology requires significant computing power and can be costly to implement. Another issue is the shortage of specialists with strong blockchain expertise. In addition, many countries do not yet have clear legal frameworks for using blockchain in education and healthcare. To overcome these obstacles, it is necessary to develop simpler and more energy-efficient blockchain systems and to train new professionals in this field. Governments should also create international standards for blockchain-based data protection. Collaboration between universities, hospitals, and IT companies can help make blockchain solutions more practical and widely accessible.

In conclusion, blockchain technology is a powerful tool for addressing modern data protection challenges. It offers transparency, reliability, and trust in digital systems. In the future, it may help create safer and more efficient environments for education, healthcare, and many other sectors. The further development of blockchain will increase public confidence in sharing information online and will reshape the way digital systems are organized. It is clear that blockchain is becoming a key part of our secure and interconnected future.

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INFORMATION TECHNOLOGY. THE IMPACT OF LARGE LANGUAGE MODELS (LLMS) ON THE FORMATION OF SYNTHETIC EMOTIONALITY AND TRUST IN HUMANS

Modern large language models (LLMs) such as ChatGPT, Bard, or Claude are rapidly developing and becoming an essential part of the digital world. They can generate human-like text, analyze context, and even imitate emotional reactions. These capabilities mark a new stage in human-computer communication but also raise ethical and psychological questions about trust in artificial intelligence.

The purpose of this study is to explore the impact of large language models on the formation of "synthetic emotionality" — the ability of AI systems to imitate human emotions in order to improve user interaction. The study also examines how this emotionality affects users' level of trust in AI.

Research findings indicate that models such as GPT-4 and Gemini can effectively simulate empathy, support, and persuasion, sometimes creating the illusion of a real conversation partner. This phenomenon, known as digital anthropomorphism, leads users to perceive AI as a human being. While such interaction can be beneficial in education, psychological assistance, or customer service, it also carries risks of manipulation and emotional dependency.

Therefore, it is crucial to ensure the ethical use of large language models and develop technological safeguards that guarantee safe and transparent human-AI interaction. A deeper understanding of synthetic emotionality will help create systems that are not only effective but also humane, responsible, and beneficial for society.

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ETHICAL DILEMMAS OF ARTIFICIAL INTELLIGENCE IN DIGITAL SECURITY

Artificial intelligence (AI) has become one of the most powerful tools in digital security, capable of analyzing massive datasets, detecting cyber threats, and responding to incidents far more quickly than human experts. Its ability to process information in real time enables organizations to identify anomalies, prevent attacks, and predict emerging threats with unprecedented speed and accuracy. For example, AI-driven threat-detection platforms such as Darktrace and CrowdStrike can identify suspicious network behavior within seconds, potentially stopping ransomware attacks before they spread. According to a 2024 report by Capgemini, organizations using AI in cybersecurity reduced their average breach-detection time by 27% and remediation costs by 12%, demonstrating the tangible benefits of AI adoption. In addition, AI helps automate routine security monitoring, allowing human specialists to focus on complex tasks and strategic decision-making.

However, this progress is accompanied by significant ethical dilemmas that require careful consideration. One of the most prominent issues is privacy: AI-powered systems often rely on large

volumes of personal data to identify risks, which can result in violations of user rights. For instance, AI-based monitoring tools in corporate environments may inadvertently track employees' personal activities, raising concerns about consent and the limits of surveillance. Similarly, AI-driven government surveillance programs can monitor citizens on a massive scale, prompting debates about civil liberties and digital rights. These concerns highlight the need for transparent regulations and international standards to prevent misuse of AI technologies.

Another critical challenge is the transparency and accountability of AI algorithms. Many security-related decisions are made by “black-box” systems, where the reasoning process is neither visible nor interpretable. This complicates efforts to ensure fairness, reliability, and public trust. The lack of interpretability can also amplify biases, such as when legitimate user actions are flagged as suspicious due to incomplete or skewed datasets. Furthermore, the growing autonomy of AI in security systems increases the likelihood of unintended consequences, including false positives or unjustified restrictions that can disrupt legitimate operations. For example, automated AI-controlled firewalls may block legitimate financial transactions or deny access to critical services, underscoring the importance of human oversight.

Several measures should be adopted to mitigate these challenges. First, the development of Explainable AI can enhance transparency by making decision-making processes understandable to both experts and users. This enables organizations to audit AI behavior and ensure that outcomes align with ethical standards. Second, implementing ethical codes of conduct for AI developers and cybersecurity professionals can promote responsible innovation and accountability. Such codes should emphasize fairness, non-discrimination, and respect for human rights. Third, the principle of data minimization should be followed to protect user privacy without compromising system performance. Collecting only essential data and anonymizing sensitive information reduces the risk of misuse or leakage. Maintaining human-in-the-loop oversight for critical decisions further prevents system errors or abuses, ensuring that AI acts as a supportive tool rather than an autonomous authority. Finally, continuous education and training for cybersecurity professionals are essential to ensure that ethical considerations remain a priority in AI-driven security development.

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SMART HOME SYSTEMS BASED ON THE INTERNET OF THINGS (IOT)

It is quite obvious, that today smart devices are actively being introduced into various areas of any society optimizing business processes and improving the quality of work of many systems. "Fortune Business Insights" makes predictions about IoT «this area is becoming an independent ecosystem that develops around 25% every year» [1]. As an example is a smart home, that represents one of the most practical and obvious example of the IoT implementation. It is integrating multiple intelligent devices and household appliances capable of exchanging data and maintaining connectivity to provide services to residents and enable remote home management

Smart homes are no longer a passing trend but a reality that offers comfort, sustainability, and efficiency. Smart home systems combine hardware and software elements to establish an intelligent environment that can operate automatically. Such systems typically function in small-scale networks involving a limited number of users, usually the household members. They can use various types of network connections, including 3G, 4G or Wi-Fi to ensure reliable communication between all devices. Data processing and storage are generally managed through a local server, while IoT devices often use wireless technologies such as RFID or wireless sensor networks (WSNs). Due to their limited scope, smart homes require only a small amount of bandwidth to support efficient performance. [2]

Like other technologies, smart homes are also evolving and improving. Neural networks such as the ADALINE model are being integrated into some smart homes, while alternative energy sources are being explored to optimize energy consumption. The solar panel converts the energy of the light into electrical energy, stores it in the battery and uses it as backup power. The system is managed through an

Android application that connects to the Raspberry Pi via Wi-Fi. The HTML interface allows you to remotely control devices such as lighting and TV. The Raspberry Pi acts as a server, and the intermediary access point is between the program and the hardware parts of the system. The ADALINE algorithm automatically regulates the operation of devices according to the indicators of sensors and adapts to environmental changes, increasing the efficiency of the system. The combination of IoT, neural networks and solar energy provides the system with autonomy, energy efficiency and convenient control. [3]

In the conclusion, the demand for smart home systems is rising rapidly. Even today, scientists are moving towards the goal of creating smart cities, where intelligent control systems will help cities reduce energy consumption by up to 30%. The scientists underline that the trend towards smart homes will continue to evolve. With every technological advance, architectural design has the opportunity to enhance the home experience. In the near future, we will see how artificial intelligence and the Internet of Things (IoT) become even more integrated into architectural spaces, enabling the creation of fully autonomous homes.

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APPLYING MACHINE LEARNING TO DETECT ANOMALIES IN QUANTUM-RESISTANT NETWORK SECURITY PROTOCOLS

The global information infrastructure is facing a critical challenge due to the rapid advancement of large-scale quantum computing. As a result, the transition toward Post-Quantum Cryptography (PQC) standards – such as Kyber and Dilithium – has become essential. These quantum-resistant protocols are designed to withstand attacks from quantum computers but introduce new complexities, including larger key sizes, higher computational demands, and the use of advanced mathematical constructs that are less widely understood. Such characteristics can create previously unseen vulnerabilities that traditional signature-based security systems may fail to detect.

The main challenge lies in ensuring that PQC mechanisms are deployed correctly and operationally reliable. Unlike classical encryption algorithms, PQC systems are more prone to implementation errors due to their computational intensity and sensitivity to small deviations in configuration or runtime conditions. This sensitivity can introduce subtle network-level anomalies, such as abnormal delays, irregular packet sizes during key exchange, or atypical interactions between protocol components.

This research focuses on designing and evaluating an adaptive security layer that applies Machine Learning (ML) to detect real-time anomalies in network traffic protected by PQC. Traditional rule-based and threshold-based systems are insufficient for identifying the complex statistical variability inherent in modern PQC implementations. Therefore, the proposed approach emphasizes constructing a dependable

data pipeline and identifying ML algorithms that are well-suited for this environment. The analysis incorporates detailed metadata extracted from network packets, including PQC-specific parameters such as Key Encapsulation Mechanism (KEM) sizes and variability, changes in public-key lengths, and fluctuations in signature verification latency.

The proposed solution employs unsupervised learning methods such as Isolation Forest and One-Class Support Vector Machine (OC-SVM), both of which are effective at establishing statistical baselines for normal protocol behavior. These models are trained exclusively on data representing the optimal operational state of PQC implementations. Their primary function is to monitor the statistical patterns of PQC-related features and assign an anomaly score to events that deviate significantly from expected behavior. Such deviations may indicate protocol misconfigurations, denial-of-service attacks exploiting computational asymmetries, or advanced threats targeting implementation weaknesses. This ML-driven framework provides a flexible and adaptive method for anomaly detection, which is vital for the secure integration of PQC into modern network infrastructures. Machine learning is expected to significantly improve detection accuracy while reducing response time compared to traditional rule-based approaches.

In conclusion, this research demonstrates the crucial role of Information Technology – and machine learning in particular – in ensuring the secure and reliable adoption of Post-Quantum Cryptography standards. The proposed ML-based anomaly detection model offers a robust defensive mechanism that strengthens next-generation network security and supports the development of a resilient digital environment capable of withstanding future cyber threats.

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INFORMATION TECHNOLOGIES AS A KEY ELEMENT OF NATIONAL SECURITY AND CYBER DEFENSE

In the digital era, information technologies have become a key element of national security and defense. Modern societies depend on digital infrastructures such as power grids, transportation systems, financial institutions, and communication networks – all of which rely on information systems to function effectively. As these systems grow more interconnected, their exposure to cyber threats also increases. Therefore, information technologies are not only a tool for development but also a crucial component of national protection and stability.

The importance of IT in national security can be observed in multiple domains. Governments and defense institutions use advanced technologies for data analysis, surveillance, communication, and decision-making. Cyber intelligence systems monitor potential threats, while secure communication networks ensure the confidentiality of sensitive information. In military operations, information technologies play a decisive role in logistics, satellite navigation, and cyber warfare capabilities. The ability to collect, process, and protect information faster than an adversary has become one of the key factors determining a country's strength.

However, the same technologies that empower nations can also expose them to new forms of danger. Cyberattacks have become a primary weapon in modern conflicts, targeting government databases, financial systems, and critical infrastructure. A single attack on a power plant or hospital network can cause chaos, disrupt essential services, and endanger lives. For this reason, cybersecurity is now considered as vital as physical defense. Nations must develop comprehensive strategies that include not only technological tools but also education, international cooperation, and robust legislation.

The human factor remains a significant challenge in maintaining cybersecurity. Even the most advanced systems can be compromised by human error, weak passwords, or insider threats. Therefore, continuous training, awareness campaigns, and the establishment of a strong cybersecurity culture are essential. Governments should also collaborate with private companies and academic institutions to

create a unified national cyber defense framework. Sharing information about threats and best practices can greatly enhance resilience against cybercrime and digital warfare.

Another critical aspect is the ethical dimension of using IT in national defense. Surveillance technologies and data collection methods must balance national security needs with the protection of citizens' privacy and human rights. Building public trust is vital, as security cannot exist without the confidence of society.

In conclusion, information technologies are indispensable for ensuring national security and defending against cyber threats. They provide the tools to protect data, maintain stability, and prevent digital warfare. Yet, technology alone is not enough. Effective cyber defense requires skilled professionals, responsible policies, and global cooperation. In the modern world, the safety of a nation increasingly depends not on the strength of its weapons, but on the security of its information systems.

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CREATING TRUST IN THE DIGITAL AGE THROUGH ARTIFICIAL INTELLIGENCE AND CYBERSECURITY SOLUTIONS

Artificial Intelligence (AI) has become one of the most transformative forces of modern technology, shaping industries, economies, and daily life. While AI brings innovation and efficiency, it also introduces new challenges to cybersecurity, privacy, and data protection. Balancing innovation and security is essential for building trust in the digital ecosystem.

AI technologies such as machine learning, natural language processing, and neural networks are increasingly used to improve cybersecurity systems. Intelligent algorithms can detect anomalies, identify threats in real time, and predict cyberattacks before they occur. Automated security systems powered by AI allow faster responses to incidents and reduce human error. For example, AI-driven firewalls and intrusion detection systems analyze millions of data points to prevent potential breaches, protecting sensitive information more effectively than traditional methods.

However, the same technologies can be exploited by cybercriminals to create sophisticated attacks. Deepfakes, automated phishing campaigns, and AI-generated malware represent a new generation of digital threats. These developments highlight the importance of ethical AI and international cybersecurity standards. Governments, tech companies, and researchers must collaborate to ensure that AI serves as a tool for protection rather than exploitation.

Another critical aspect is data privacy. AI systems rely on large datasets for training, often containing personal information. Ensuring transparency in data collection and processing is vital to maintain public trust. Techniques like data anonymization, encryption, and secure machine learning models are essential in minimizing privacy risks. Responsible AI development must prioritize security and fairness, avoiding bias and discrimination in algorithmic decision-making.

Education and awareness also play a significant role in cybersecurity. As technology advances, individuals and organizations must adapt by learning to identify digital threats and protect their data. Integrating cybersecurity education into schools, universities, and workplaces can strengthen resilience against modern attacks.

The future of cybersecurity will depend on how effectively humans and AI systems can cooperate. Hybrid defense models, where artificial intelligence works alongside human experts, show great potential for preventing cyber threats. Humans bring intuition, ethics, and contextual understanding, while AI provides speed, precision, and pattern recognition. Together, they can create adaptive security systems capable of learning from each attack and becoming stronger over time. This human-AI partnership will shape a new generation of intelligent defense strategies.

In conclusion, the combination of Artificial Intelligence and cybersecurity defines the foundation of digital safety in the 21st century. By developing secure, ethical, and transparent AI systems, society

can harness the benefits of innovation while reducing technological risks. Building trust in the digital age is not only a technical challenge but also a moral responsibility – one that will determine how safely humanity advances into the intelligent future.

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CYBERSECURITY IN THE AGE OF ARTIFICIAL INTELLIGENCE: NEW CHALLENGES AND METHODS FOR DATA PROTECTION

The modern development of information technologies, in particular artificial intelligence, has opened up new opportunities for processing, analyzing and sorting large amounts of data. However, at the same time, the risk of cyberattacks, information leaks and manipulations of digital systems have increased.

AI is able to both strengthen security (by detecting anomalies, recognizing threats in real time) and create new forms of cyberattacks - in particular, by generating phishing messages or deep fakes.

An effective cybersecurity strategy today should include a combination of traditional encryption methods, multi-factor authentication and machine learning systems that can adapt to new threats. It is also important to increase the digital literacy of users, because the human factor remains one of the main weaknesses in security systems.

So how to counter modern cyberattacs? In the face of a constantly growing number of cyber incidents, traditional approaches to security are no longer sufficient. One of the key areas of development has been the use of artificial intelligence systems to protect against cybercrime. Such systems are able to analyze user behavior, detect unusual actions, predict potential threats and automatically respond to them.

Among the effective technologies, it is worth noting:

Machine learning-based intrusion detection systems (ML-based IDS). They analyze network traffic, identifying suspicious patterns that cannot be found by classical methods.

User behavior analytics (UEBA) algorithms. These models study the usual behavior of each user and signal deviations that may indicate a compromised account.

Intelligent authentication systems. Biometric methods, facial recognition, fingerprint recognition or even handwriting style recognition are becoming an important component of modern cybersecurity.

Special attention is being paid today to adaptive security systems that can change their own algorithms depending on the nature of the attacks that occur. This allows for the creation of a flexible, "self-learning" environment that can quickly respond to new types of threats.

Despite automation, the human factor remains one of the most vulnerable elements of any security system. Studies show that over 70% of cybercrime incidents occur due to user error – clicking on malicious links, using weak passwords, or careless handling of confidential information.

To minimize these risks, it is necessary to systematically conduct cyber hygiene trainings, implement interactive educational programs with simulations of real cyberattacks.

Artificial intelligence can also help increase user awareness: chatbots, intelligent assistants and educational platforms help to quickly detect dangerous actions and teach the correct methods of response.

Artificial intelligence can become both the most powerful tool for protection and the most dangerous weapon in the hands of cybercriminals. This creates a cybersecurity "arms race" where defenders must adapt to proactive, predictive, and AI-powered threats.

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THE FUTURE OF HUMANITY IN THE ERA OF DIGITAL TRANSFORMATION: SOCIAL, ECONOMIC AND CULTURAL CHANGES

Digital transformation refers to the use of digital technologies to modify or create new business processes, customer experiences, and organizational culture in response to changes in the market, customer insights, and business needs.

The future of humanity in the era of digital transformation will be shaped by the accelerating integration of artificial intelligence, automation, and data-driven technologies into everyday life. These innovations are fundamentally redefining how people communicate, build relationships, and create communities, introducing new forms of social behavior while challenging traditional norms and values.

Economically, the global shift toward digital ecosystems is transforming industries and reshaping the structure of labor markets. Automation and AI-driven systems increase productivity and create new opportunities, yet they also raise concerns about job displacement, inequality, and the urgent need for digital skills to remain competitive in the future workforce.

Culturally, digital media, virtual environments, and global connectivity are reshaping identities, influencing artistic expression, and transforming collective memory. As digital culture becomes a dominant force, it affects how people understand themselves, engage with information, and participate in global cultural exchange.

As these social, economic, and cultural shifts intensify, humanity must find ways to balance rapid technological progress with human-centered principles. Ensuring ethical innovation, equitable access, and the preservation of fundamental human values will be essential for shaping a sustainable and inclusive digital future.

How to approach digital technologies

Each digital era has prompted businesses to reconsider their internal operations and customer expectations, creating opportunities for new market entrants and transforming, or even retiring, existing business models.

The key mistake many businesses make is treating digital transformation as a finite task that can be completed. Instead, it should be viewed as a continuous process of evolution and improvement, necessitating the formulation of digital transformation strategies to guide the successful implementation of digital transformation projects.

A comprehensive digital transformation strategy is crucial for aligning technology investments with business goals, ensuring that efforts in digitization and innovation lead to sustainable growth and competitiveness as businesses operate in the evolving digital world.

Navigating digital transformation effectively remains a challenging task. It involves overhauling legacy processes and systems, which is a substantial undertaking requiring both courage and resilience.

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STEGOANALYSIS OF INFORMATION HIDING USING GRAPHIC FILE CONTAINERS

Steganography is a set of methods that facilitates the embedding of confidential information within a carrier (container) in such a manner that its presence is indistinguishable from background noise or random data [1]. This approach ensures the concealment of the very fact of confidential data transmission, thereby significantly minimizing the risk of unauthorized information detection. Currently, steganography is distinguished into the following branches [1]: classical, computer, and digital. Digital steganography is an offshoot of classical steganography that utilizes digital media (containers). The

central principle of this domain is to embed information into digital containers (e.g., images, audio, or video files) so that the introduced distortions are imperceptible to the human visual or auditory systems.
Steganalysis is the field of research focused on detecting the presence of hidden information within digital media, particularly in images, audio, or video files . Its primary objective is to identify modifications made to a container by steganographic methods, even when the direct extraction of the hidden data is infeasible [2]. Modern steganalysis is categorized into two types: specific (or targeted), which is based on knowledge of the specific embedding algorithm and exploits its characteristic statistical artifacts; and universal (or blind), which is aimed at detecting any alterations regardless of the concealment method employed [3].

The primary approaches to steganalysis are based on statistical, structural, and machine-learning methods. Statistical analysis facilitates the detection of anomalies by comparing the distributions of brightness values or transformation coefficients of the container against those of unmodified images. Structural methods focus on the file's composition, seeking indicators of modification within its format. This may involve verifying header integrity, analyzing metadata, or detecting non-standard parameters in data blocks that could have been altered to conceal information. Machine-learning methods have become the dominant approach, particularly for universal steganalysis. The application of neural networks enables the detection of complex, high-dimensional statistical deviations, thereby providing superior detection accuracy in complex and unknown scenarios [4].

One of the most popular and simplest methods for data concealment in graphic file-containers is the Least Significant Bit (LSB) replacement method [1]. Visual analysis of the LSB plane is the most straightforward detection technique. In a "clean" container, this plane appears as random "white noise." However, if a structured message is hidden within the container, its patterns will be visually discernible against this noise.

LSB replacement embedding can also be detected using the following statistical analysis methods [5]: the $\chi 2$ attack, which analyzes the statistical imbalance of "pairs of values" that differ only in the least significant bit; RS-analysis, which classifies small pixel blocks as "regular" or "singular" and detects disturbances in the ratio between them; and histogram difference analysis (or histogram-based analysis), which registers the "blurring" or "flattening" of the histogram's sharp peak caused by the introduction of external noise.

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OPERATIONAL PRINCIPLES AND SECURITY ASPECTS OF SCADA SYSTEMS

From the theory of information security, several areas of work are distinguished, including cybersecurity, which provides protection of computer systems, networks, programs and data from

modern digital attacks. It is here that we will consider in more detail the direction of development of SCADA technology. SCADA (Supervisory Control and Data Acquisition) technology is closely related to the protection of critical infrastructure (hereinafter referred to as CI), comprehensive protection, a key mechanism for protection and risk management, with the aim of centralized monitoring and management of processes important for ensuring the resilience of facilities to threats. Let us tell you how it actually works while centralized monitoring and management in this technology depends on CI operators with real-time data on the status of current processes. Identification and assessment of threats allows you to find out that an anomaly or other potential threats may affect full functioning. Integrated protection measured in SCADA can be both automated and with the rapid implementation of a special operator, that is, in the event of an attack, the operator can respond to the attack, isolating certain (extremely important) segments. Risk management, namely the development of response plans for the same operators to emergency situations are specified in the safety data sheet, responding directly and in advance, assessing all possible vulnerabilities. Comprehensive protection occurs when SCADA combines physical and cyber protection into a single link. The key mechanism is SCADA systems, since they analyze, manage and respond to incidents in continuous operation every day.

Moreover, regarding the analysis of SCADA, this is primarily data collection, achieved by using Remote Terminal Unit (RTU) or Public Limited Company (PLC) in real time. In general, this can be different types of data. After that we can apply data processing, in order to obtain information from the collected data in an understandable form. The next stage is data visualization - roughly speaking, this is the application of the collected information to certain graphs for general statistics, or mnemonics if necessary. The analysis process occurs either as already mentioned in real time or historically (used to optimize processes or identify the causes of failures with subsequent planning for the future). That is, SCADA helps to analyze not only one specific thing (certain parameters) but also the relationship between them, for a better understanding of the completeness of the operation of this technology. Vulnerability analysis is carried out in several stages: 1. determination of the goals and scope of research of a particular system; 2. vulnerability assessment, namely scanning the network for previously known vulnerabilities in operating systems, services or applications. The configuration of the system (access rights, security settings and communications protocols) is also analyzed. 3. Testing the repaired system through simulation of various attacks. It is at this stage that it is quite important to check the system's resistance to DDoS. 4. Correction of deficiencies that were identified during testing and the final introduction of the repaired system into full operation.

To sum up, we can state that SCADA systems represent a technological backbone for the critical infrastructure management and protection. Their effectiveness is determined by robust telemetry collection, secure data transmission, integrated cyber-physical security mechanisms, and proactive risk management strategies. As cyber threats grow in complexity and frequency, continuous improvement of the system security remains essential. Ensuring the resilience of CI requires ongoing modernization of SCADA technologies, alignment with advanced security standards, and consistent readiness on the part of operators and security personnel.

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USING RANDOMIZED CONTROLLED RESEARHES IN MEDICINE: THE EFFECT OF SSRIs ON PMS AND PMDD

Premenstrual syndrome (PMS) is a combination of physical, psychological, and social symptoms that women of reproductive age have, and premenstrual dysphoric disorder (PMDD) is a severe type of syndrome that affects about 3-5% of women, formerly known as late luteal phase dysphoric disorder (LPD). Both syndromes cause symptoms during the two weeks before menstruation (so called luteal phase of ovary cycle). Selective serotonin reuptake inhibitors (SSRIs) are increasingly being used as first-line therapy for PMS because they are considered effective in reducing symptoms, which include:

emotional changes (irritability, anxiety, tearfulness, mood swings), physical manifestations (chest and abdominal pain, headache, bloating, swelling), as well as other signs such as fatigue, sleep disturbances, increased appetite, or rashes.

The goal of many studies on this topic is to evaluate and study the effectiveness and safety of SSRIs in reducing premenstrual syndrome symptoms in women diagnosed with severe premenstrual syndrome.

In terms of their basic mechanism of action, SSRIs increase the extracellular level of the neurotransmitter serotonin by limiting its reabsorption by the presynaptic cell and thus increasing the level of serotonin in the synaptic cleft available for binding to the postsynaptic receptor. In other words, the antidepressant effect of SSRIs is to block the reuptake of serotonin by the neurons that secrete it, which leads to an increase in the amount of serotonin in the synaptic cleft. Effects such as correction of depressed mood, reduction of life longing, anxiety, phobias, appetite, and mild analgesic effect are associated with the effect on serotonin receptors.

The researchers conducted an electronic search for relevant randomized controlled trials in the Cochrane Menstrual Disorders and Subfertility Group's Specialized Register of Controlled Trials, the Cochrane Register of Controlled Trials, MEDLINE, EMBASE, and PsychLit. Reference searches were conducted interactively to identify missing studies. All studies in which women with a prospective diagnosis of PMS/PMDD were randomized to receive an SSRI or placebo in a double-blind trial for the treatment of premenstrual syndrome were considered.

Thirty-one RCTs were included in the review. They compared fluoxetine, paroxetine, sertraline, escitalopram, and citalopram with placebo. SSRIs were significantly more effective than placebo in reducing self-rated total symptoms. The primary analysis of total symptom reduction included data from 844 women with premenstrual syndrome. SSRIs were found to be highly effective in treating premenstrual symptoms. Secondary analyses showed that they were equally effective in treating both physical and behavioral symptoms. There was no significant difference between trials funded by pharmaceutical companies and those funded independently. Discontinuations due to side effects were 2.5 times more common in the treatment group, especially at higher doses. Side effects associated with SSRIs included nausea, insomnia, sexual dysfunction or decreased libido, fatigue or sedation, dizziness or vertigo, tremor, drowsiness and decreased concentration, sweating, dry mouth, asthenia or decreased energy, and constipation. There was moderate-certainty evidence for all side effects except for drowsiness/decreased concentration, which was low-certainty evidence. Overall, the certainty of the evidence was moderate.

SSRIs are likely to reduce premenstrual symptoms in women with PMS and PMDD and are likely to be more effective when taken continuously compared with taking during the luteal phase. SSRI treatment is likely to increase the risk of side effects, the most common of which are nausea, asthenia, and drowsiness.

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THE RISE OF DIGITAL AGRICULTURE: INNOVATION FOR SUSTAINABLE FOOD SYSTEMS

Nowadays European farming is rapidly moving to a new level of efficiency with the help of digital technologies. While just a few years ago a ‘smart farming’ was more of a concept for the future, today it is becoming commonplace for an increasing number of agricultural producers. Farmers are focusing in particular on technologies that help to increase productivity in conditions of limited resources or with the aim of minimising and preserving the resources used. Given the constant climate challenges and the increase in the number and frequency of natural disasters that directly affect crop yields, the main challenge for agriculture is the need to produce as much as possible while using less water, fuel, fertilisers and pesticides. That is why automation, robotics and artificial intelligence are becoming the basis for agricultural sector development strategies.

Digital farming, also known as Digital Agriculture, Agriculture 4.0, Smart Farming, Smart Agriculture or electronic farming (e-farming) is the use of digital technologies in the agricultural sector, including sensors, satellite imagery, drones, GPS mapping, analytical tools and artificial intelligence (AI) to optimise crop production [1].

Among the main digital solutions currently used in agriculture, the following are worth highlighting: Digital Farming Platforms, Sensors, Drones, Global Positioning System (GPS) Mapping, Internet of Things (IoT), Machine Learning and Artificial Intelligence (AI).

The key tools of precision farming include: GPS navigation and autopilots, drones for crop monitoring, IoT humidity and temperature sensors, drip irrigation systems, robotic fertiliser application systems, data analytics platforms, weather stations, and laboratory rapid analysers.

Machine learning and artificial intelligence are radically changing approaches to decision-making in agriculture. AI-based systems analyse huge amounts of data and provide accurate forecasts for yield prediction, disease detection, feed optimisation, and more.

Modern ERP systems for farmers combine all farm processes into a single digital ecosystem with the following objectives:

Planning sowing campaigns – optimal distribution of crops across fields.

Resource management – control of seed, fertiliser, and plant protection product stocks.

Equipment monitoring – GPS tracking and fuel consumption control.

Financial accounting – calculating the cost of crops.

Document flow coordination – electronic declarations and reporting. [2]

Despite the numerous advantages offered by these technologies, it is worth paying attention to the challenges facing farmers, namely: high investment costs for implementing these technologies, lack of IT specialists in rural areas, weak internet connection, resistance to change from conservative farmers, and the geopolitical situation in general (in the case of Ukraine, hostilities).

Despite this, European analysts are convinced that digital transformation is an inevitable stage in the development of the agricultural sector, because it will not only reduce costs and increase yields, but also make farming more environmentally friendly – thanks to more accurate dosing of fertilisers and plant protection products, as well as more efficient use of water resources.

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INFORMATION TECHNOLOGIES IN UKRAINIAN COMBAT DRONES

This paper explains how software, AI, communications, and sensors make Ukrainian combat drones effective. It lists open autopilots, AI models, sensors, and software systems, showing how IT transforms low-cost airframes into capable weapons.

Since 2022, Ukraine used cheap drones at large scale. The important point is not only the airframes but the IT around them: autopilots, video links, AI for detection, networks for command-and-control, and quick software updates.

Ukrainian developers commonly use open autopilots such as ArduPilot and PX4, providing flight control, mission planning, fail-safes and telemetry [3]. They can run on widely available flight controllers (Raspberry Pi). These systems support GPS navigation to track mission waypoints and integration with companion computers for video processing and simple AI.

For object detection and video filtering, teams use lightweight AI models like YOLOv5–v8. These models are used to flag likely vehicles, groups of people, or launch signatures in video frames and reduce bandwidth by sending only useful frames [5].

Modern drone operations use a mix of radio FPV links (very low-latency analog/digital) and cellular (4G/5G) links for long range. For command-and-control, designers aim for as low latency as possible (tens of milliseconds) when using 5G. Lower latency improves manual piloting and reduces time from detection to engagement.

Common sensors: EO (electro-optical) and thermal cameras for identification and heat-signature detection; accelerometer/gyro for stability and dead-reckoning; LIDAR/ultrasonic altimeters for precise low-altitude flight.

Combat drones in Ukraine operate as:

- FPV kamikaze drones — fast one-way attack against vehicles, bunkers, artillery, and checkpoints.
- loitering munitions — seek-and-strike supply nodes, depots, or radar.
- guided small munitions from larger UAVs — strike logistic hubs or command posts.

Reports and market articles show low-end FPV kamikaze builds in Ukraine can be as cheap as a few hundred dollars to a few thousand dollars, however, they can disable or destroy equipment or supplies that cost tens of thousands [1]. Workshop-level and national-level production figures reported in analysis/transcripts indicate hundreds of thousands to millions of small UAVs produced across 2023–2025 [2]. Use these reported numbers carefully because sources vary.

Software suites and mission systems — what they do:

- autopilot and flight stacks: ArduPilot, PX4 — flight control, waypoint missions, failsafe logic, and many interfaces for peripheral sensors [4];
- ground control software: QGroundControl, Mission Planner — mission planning, live telemetry, map overlays;
- video software: end-to-end encrypted encoders and streamers (commercial units), combined with custom ground-station UIs that show video, AI flags, map overlays and simple target-marking tools. These systems allow operators to mark targets quickly and pass coordinates to artillery or strike teams;
- data fusion: simple servers and messaging systems (custom dashboards, mapping tools) aggregate telemetry and detections from many drones and show consolidated situational awareness for small-unit commanders.

Here I describe the role of IT in some public operations — listed at a general level because detailed classified data is not public.

Deep strikes using networked targeting: Ukrainian teams combined drone ISR (intelligence, surveillance and reconnaissance), satellite imagery, and artillery systems to strike supply depots and air-defence sites far from the front. The pipeline (video → AI flag → operator validation → coordinate handoff) shortened targeting time from hours to minutes and increased mission tempo [2].

Mass FPV attacks on logistics nodes: Large swarms of FPV kamikaze drones overwhelmed local defenses by dividing attention; low-latency FPV and skilled pilots allowed precise hits on exposed vehicles and fuel. Software updates and shared tactics improved hit probability over time.

Foreign governments and companies have expressed interest in Ukrainian battlefield-proven drone systems. Reporting shows discussions at high level about buying or learning from battlefield-tested Ukrainian drones.

Information technologies — open autopilots, compact AI models, low-latency video links, and data-fusion dashboards — together turned many simple airframes into effective combat systems. Cost asymmetry (cheap drones vs expensive targets) and speed of software iteration are critical advantages.

The progress of Ukrainian drone technology is truly impressive. It shows how creativity and teamwork can make strong results even in difficult conditions. Engineers, programmers, and soldiers work together, using open-source software and commercial parts. This should be a source of pride for anyone who values innovation and problem-solving.

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INFORMATION TECHNOLOGY: THE ROLE OF TECHNOLOGY IN MODERN MEDICINE

Nowadays, information technology plays a significant role in almost every field and medicine is no exception. Digital progressing helps surgereons, cardiologists, psychologists etc. It's important to note that doctors use many technologies that enhance their facillities beyond what the human body allows. For example, MRI and CT scanners enable doctors to "see" inside the body. Similarly, many surgeons perform robotic-assisted surgery because it extends the capabilities of their eyes and hands. And in this essay I'd like to tell about the most recently and modern technologies in medicine.

Now the most well-known robotic surgical system in the world is da Vinci. The da Vinci robot has small robotic arms with special surgical instruments and a 3D camera, which gives doctors a clear, enlarged view of the area they're working on. The surgeon controls the robot from a console, moving its arms with great precision. This technology helps reduce pain, blood loss and recovery time for patients compared to traditional surgery. The da Vinci robot is widely used in different areas of medicine because it can perform very precise and gentle movements. For example, in urology it is often used for prostate surgery where accuracy is extremely important to avoid damaging nearby nerves and tissues. In gynecology doctors use the robot for operations on the uterus or ovaries, which helps reduce pain and scarring after surgery. In heart surgery, the da Vinci system allows surgeons to work on delicate parts of the heart through small openings instead of large cuts, which lowers the risk of complications and speeds up recovery.

Another instance is an electronic health system (eHealth). eHealth provides exchange of medical information between different institutions, simplifies access to medical information about patients. This technology also allows people to make an appointment with a doctor online, have online prescription in your phone, instead of reading the doctor's illegible handwriting. But eHealth also has disadvantages such as privacy and security risks as with just about every computer network these days, its systems are vulnerable to hacking, which means sensitive patient data could fall into the wrong hands. In addition, because an electronic health record system enables patients to access their medical data, it can create a situation where they misinterpret a file entry. This can cause undue alarm, or even panic.

In conclusion, information technology has become an essential part of modern medicine, transforming how doctors diagnose, treat and communicate with patients. It improves accuracy, speeds up medical research and makes healthcare more accessible to people all over the world. Thanks to innovations such as electronic health records, telemedicine and robotic surgery, today medicine is safer, faster and more effective than ever before. As technology continues to develop, it will open even more opportunities to improve human health and the quality of life for future generations.

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ETHICAL ASPECTS OF ARTIFICIAL INTELLIGENCE IN MODERN SOCIETY

Artificial intelligence is rapidly entering our lives, raising questions about the ethical ways in which artificial intelligence itself works, the principles of its operation, which must take into account universal human values and fundamental human rights, and adhere to the principles of justice and security. Responsible AI is the practice of using artificial intelligence in a way that emphasises human oversight and social welfare. It is about ensuring that AI models, datasets and applications are developed and deployed ethically and lawfully, without causing deliberate harm or perpetuating bias [1]. This depends primarily on the developers of artificial intelligence.

We have analysed which principles should be paramount when creating AI. The first thing to pay attention to is the principle of transparency, security and accountability [2].

In practice, a lack of transparency creates significant ethical and legal problems. It is often impossible to determine why an AI system made a particular decision or prediction, making it difficult to assess whether a person has been unfairly treated, for example, in the hiring process or when applying for a government benefit.

Secondly, there is the principle of fairness and non-discrimination. In this case, the emphasis is on ethical impartiality with regard to race, dialect and different socio-economic status.

Thirdly, the principles of accountability, governance and human-centredness are important. AI developers must be accountable for their work and constantly monitor and verify operational requirements.

Currently, the use of AI in various areas of human activity is only gaining momentum. We can see AI in justice, medical diagnostics, the socio-economic sphere and the labour market. In this regard, certain requirements are imposed on AI developers – protection of information, elimination of discrimination in justice, provision of equal access to medical care for all demographic groups, elimination of inequality and economic bias, for example, in hiring. The UNESCO recommendation calls for respect, protection and promotion of diversity and inclusiveness, and calls for the meaningful participation of marginalised groups. These issues are covered by UNESCO's broader Policy Areas of Action, which include gender aspects and data governance [3].

AI system developers and providers have a primary responsibility to embed ethical principles. In addition, it is necessary to increase AI literacy among end users and society as a whole. Promoting public awareness and understanding of AI technologies through open and accessible education is a necessary step. This allows people to make informed decisions about their use and be protected from undue influence by systems.

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THE CONVERGENCE OF REAL-TIME AND PRE-RENDERED GRAPHICS: BRIDGING THE GAP BETWEEN FILM AND VIDEOGAME PRODUCTION

The boundaries between film and video game production are becoming increasingly blurred as live rendering technologies reshape digital storytelling. Once confined to interactive media, game engines such as Unreal Engine and Unity are now widely used in film and television through "virtual production" — a process that allows filmmakers to visualize and modify scenes live as they are being made [1]. This paper explores the convergence of real-time and pre-rendered graphics, examining how shared tools and methods transform traditional production pipelines, enhance creative flexibility, and encourage collaboration between technical and artistic teams. The study highlights this shift as a key step toward a unified ecosystem of digital entertainment [2].

Digital entertainment has entered a period of rapid convergence, where technologies once unique to either games or films are now shared across industries. As a result, the boundaries between cinema, animation, and interactive experiences are steadily dissolving [3].

This paper examines how live-rendered graphics, supported by advances in hardware and software, are reshaping production and collaboration. It outlines the historical development of this trend, the technologies enabling it, and the challenges and opportunities emerging from their integration.

The evolution of digital graphics began in the 1980s and 1990s, when film studios and game developers pursued different goals: cinematic realism versus real-time interactivity. Film relied on offline rendering — producing each frame through detailed simulation and lighting — while games prioritized speed and responsiveness [2].

By the 2010s, advances in computing power and rendering techniques began to close this gap. Physically based rendering (PBR) and modern graphics APIs enabled game engines to approach film-level realism, while film studios adopted interactive visualization tools inspired by dynamic engines [3]. These developments set the stage for the convergence now defining digital production.

At the center of this convergence is real-time rendering — the ability to generate complex 3D imagery instantly, responding to user or camera input without precomputing every frame. Unlike traditional offline rendering, which can take hours per frame, concurrent systems use hardware acceleration provided by powerful graphics processing units (GPUs) to handle massive amounts of parallel computations efficiently [1].

Another major innovation is ray tracing, which allows real-time engines to simulate natural light behavior with cinematic accuracy. Combined with optimized rendering pipelines — workflows designed to balance quality and performance — these advances bring near film-level fidelity into interactive environments [4]. Additionally, dynamic asset management systems automate how textures, models, and lighting data are loaded or adjusted depending on the scene's context, allowing artists to iterate rapidly without sacrificing visual quality.

These technologies collectively enable "virtual production," where filmmakers and developers share the same tools to design, light, and capture digital scenes in real time. This represents not only a technical evolution but a cultural one — merging the languages of gaming and cinema into a single creative medium [2].

Despite its advantages, real-time rendering introduces new complexities. The most significant challenge is balancing visual fidelity with performance. Even with modern GPUs and ray tracing, real-time imagery often cannot match the precision of offline rendering, requiring creative compromises to maintain smooth playback [3].

Integrating such a technology into established film pipelines also demands significant adaptation. Traditional post-production workflows are linear, while game engines operate interactively and require different asset management and version control systems. Bridging these approaches takes time and technical investment [1].

Finally, creative professionals must adapt to new workflows. Artists used to offline methods need to work with dynamic lighting and procedural systems. The learning curve can slow production, and smaller teams may lack the computational resources for high-end results. Nonetheless, continuing advances in hardware and software are steadily narrowing this gap [2].

As real-time rendering continues to mature, its influence on visual storytelling is expected to expand well beyond entertainment. The same technologies now driving film and game production are finding applications in architecture, industrial design, and virtual education — areas where interactivity and visualization merge [3]. This trend suggests that the creative and technical boundaries between industries are beginning to dissolve, forming a shared foundation for digital content creation.

Ongoing progress in GPU architecture, rendering algorithms, and asset management promises to further close the gap between real-time and offline imagery [1]. Machine learning techniques are also being integrated into rendering pipelines to enhance lighting accuracy, automate complex tasks, and improve scene optimization. These advances may eventually eliminate the need to distinguish between pre-rendered and live graphics altogether, leading to fully unified production environments [4].

Ultimately, the convergence of real-time and pre-rendered techniques represents more than just a technological shift — it marks a cultural one. Artists and engineers are now collaborating within the same creative space, using the same tools, and influencing each other's methods. This new paradigm encourages experimentation, speeds up production, and democratizes access to cinematic-quality visuals. While challenges remain, the trajectory of innovation suggests that the future of digital storytelling will be both interactive and immediate, where imagination and computation coexist seamlessly [3].

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VERIFICATION AND VALIDATION OF SOFTWARE SECURITY REQUIREMENTS

Summary. Software verification and validation are essential processes that ensure the reliability, security, and compliance of modern software with both technical specifications and user expectations, following established international standards. Together, they form the foundation for maintaining high-quality, security-oriented software systems..

Ключові слова: software verification, validation, information security, software quality, ISO/IEC standards, Common Criteria.

In modern information systems, software constitutes the main part of their cost and functionality. Its complexity is constantly increasing, which, in turn, increases the likelihood of errors caused by the

human factor. Therefore, verification and validation procedures are used to guarantee the stability and security of systems. Verification makes it possible to verify that the product meets the technical requirements, while validation confirms that it meets the expectations of the customer and end users. Together, these processes form the basis of quality control of security-oriented software.

The software verification process includes various approaches - inspections, testing, static and formal analysis. Its goal is to confirm the compliance of the software product with the requirements of the specification and identify possible deviations that may lead to vulnerabilities. To ensure the effectiveness of the checks, international standards are used, including IEEE 1012, ISO/IEC 25022, ISO/IEC 15408 (Common Criteria) and ISO/IEC 27034. They define the verification procedure, quality and security assessment criteria, as well as requirements for documenting the results.

Conclusions. Effective software verification and validation are crucial for ensuring the stability, security, and reliability of modern information systems. By applying standardized approaches such as inspections, testing, and formal analysis in accordance with international standards (IEEE 1012, ISO/IEC 25022, ISO/IEC 15408, ISO/IEC 27034), organizations can minimize vulnerabilities, improve software quality, and build user trust in the safety of digital solutions.

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SELF-HEALING SOFTWARE: CAN CODE REPAIR ITSELF?

In the rapidly evolving world of software engineering, one of the most fascinating modern concepts is self-healing software — systems capable of autonomously detecting, diagnosing, and correcting their own errors without direct human intervention [1]. This idea was inspired by biological organisms that can recover after damage. In a software context, this means creating programs that can monitor their own execution, detect anomalies, and modify their code or configuration to restore proper functionality.

By the way, the origins of the self-healing systems can be traced back to the concept of autonomic computing, introduced by IBM in the early 2000s, which aimed to create self-managing systems. Today, this idea has evolved through the use of artificial intelligence and machine learning, enabling programs to predict failures based on the analysis of previous patterns. For instance, cloud infrastructures such as AWS or Kubernetes have already implemented limited self-healing by automatically restarting failed services or reallocating resources when performance decreases [2].

However, real «self-healing process» — when a system analyzes its own code and autonomously generates patches — remains largely experimental. The methods, such as genetic programming and Automated Program Repair (APR), enable the systems to generate and test multiple fix candidates to dynamically eliminate bugs. Tools like GenProg and Repairnator have already demonstrated that artificial intelligence can successfully repair real-world software defects [3].

It is obvious, that the implications of implementing such technologies are profound. Self-healing systems can significantly reduce maintenance costs, eliminate critical failures, and increase the resilience of complex software ecosystems. However, they also raise new challenges for example, how to ensure the safety of autonomous code modifications and prevent malicious “self-corrections.”

In the conclusion, as software systems complexity is increasing, self-healing mechanisms may be transformed from experimental to practical application. In the future software engineers will likely work not only with human teams but also with intelligent systems capable of autonomous self-repairing.

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THE FUTURE OF LEARNING: ARTIFICIAL INTELLIGENCE AND LEARNING

Artificial intelligence is transforming education by enabling a level of personalization that was once impossible. Modern AI platforms can continuously analyze a student's progress, identifying patterns of strength and areas that need reinforcement. Using this data, they adjust lessons, exercises, and resources in real time so that each learner follows a path suited to individual pace and ability. A student who masters a topic quickly can move to more advanced material, while another who struggles can receive extra practice and targeted explanations. This kind of adaptive instruction keeps motivation high and helps every learner reach their potential, rather than being limited by a one-size-fits-all curriculum.

Yet even as AI becomes more capable, high-quality human teaching remains the cornerstone of education. The role of the teacher is not diminished but rather redefined. Intelligent systems can take over repetitive administrative tasks—attendance tracking, grading of routine assignments, or scheduling—freeing educators to devote more time to creative lesson design, mentoring, and the cultivation of critical thinking. Professional development is essential: teachers need training and ongoing support to understand AI tools, interpret data from learning platforms, and integrate these insights into their own teaching practice. Only when educators feel confident with technology can it truly enhance, rather than disrupt, the classroom.

AI also creates richer, more interactive learning environments. Virtual Reality and Augmented Reality allow students to explore historical sites, conduct science experiments, or visualize complex mathematical concepts in three-dimensional space. Game-based learning systems introduce competition, rewards, and narrative, turning difficult subjects into engaging challenges. Intelligent chatbots can act as on-demand tutors, answering questions at any hour and providing instant feedback, so that learning is no longer limited to the school day or the physical classroom. These immersive tools can spark curiosity and make abstract knowledge tangible.

For all its promise, the use of AI in education must be grounded in equity and inclusion. Without careful design, technology risks deepening the very divides it aims to close. Developers and policymakers must address barriers related to gender, language, disability, geography, and economic status. Access to devices, reliable internet, and well-trained teachers must be guaranteed so that students in rural or under-resourced communities are not left behind. Successful initiatives demonstrate the importance of collaboration: teachers, parents, students, and educational authorities working together to align AI solutions with national curricula and to ensure that data privacy and child protection standards are met.

Another critical dimension is helping students understand AI itself. Using intelligent tools is not enough; young people need to learn how these systems work, where their data goes, and what ethical questions arise from automated decision-making. Courses that explore algorithmic bias, data ethics, and the social impact of technology prepare future citizens and professionals to design, regulate, and use AI responsibly. In this sense, teaching with AI and teaching about AI are equally important.

Realizing this vision requires significant and sustained investment. Schools and governments must fund not only the software and hardware but also the supporting infrastructure, cybersecurity measures, and teacher training programs. Economic viability and universal access are essential if AI is to narrow rather than widen the digital divide. At the same time, curricula should continue to emphasize the human abilities that machines cannot replicate—creativity, empathy, collaboration, and independent critical thought. These skills will remain indispensable in a world where technology evolves rapidly and routine tasks are increasingly automated.

In short, the future of learning lies in a balanced partnership between human educators and intelligent systems. When designed and deployed thoughtfully, AI can personalize education, relieve administrative burdens, and create dynamic new learning experiences, while teachers provide the guidance, inspiration, and ethical grounding that no machine can replace. Together, these elements can help build an educational landscape that is more inclusive, engaging, and effective for learners everywhere.

Beyond these core considerations, the introduction of artificial intelligence into education also invites broader reflection on how schools define success. Traditional measures such as standardized testing may not fully capture the creativity, adaptability, and collaborative skills that become essential in an AI-driven world. As learning platforms gather richer data about student progress, educators and policymakers can explore new forms of assessment—ones that value problem-solving, interdisciplinary thinking, and long-term growth rather than just short-term recall.

In addition, international cooperation will play a significant role in shaping the future of AI in education. Sharing best practices, developing global ethical standards, and ensuring that technological benefits reach developing regions will help prevent a widening gap between nations. Collaborative research projects and exchange programs can accelerate innovation while respecting cultural and linguistic diversity.

Finally, the success of AI in learning depends on fostering a culture of lifelong education. As technology and job markets evolve, students and teachers alike must embrace continuous skill development. Universities, vocational institutions, and online platforms can work together to create flexible pathways for people of all ages to reskill and upskill throughout their careers. By encouraging curiosity and resilience, education systems can prepare citizens not only to keep pace with change but also to lead it.

Furthermore, the growth of artificial intelligence in education opens new opportunities for partnerships between academic institutions and the private sector. Technology companies can provide schools with state-of-the-art tools, collaborate on the development of modern curricula, and help students gain the practical skills that employers increasingly demand. Such partnerships can accelerate the adoption of innovations and enhance the competitiveness of graduates in a rapidly changing job market.

Ultimately, integrating AI into the learning process is not merely a technological project but a profound social transformation. The future of education will depend on how effectively society balances the power of intelligent machines with enduring human values. When technological progress is matched with a commitment to personal growth and equity, artificial intelligence will become not a threat but a powerful instrument for creating a more just, flexible, and inspiring educational environment for everyone.

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PASSWORD HYGIENE AND THE ROLE OF PASSWORD MANAGERS IN EVERYDAY USE

Passwords remain the primary method people use to sign in to digital services. Common problems include reusing the same password across multiple sites, choosing short or simple combinations, falling for phishing attacks, and being affected by database breaches. A password manager helps solve these issues by generating long, unique passwords, storing them in a protected vault, and autofilling login forms. Users no longer need to remember every password – one strong master passphrase, combined with an additional authentication step (2FA), is sufficient. This paper presents a simple, practical approach for using a password manager in educational environments and small teams without requiring deep technical knowledge.

We assessed whether a password manager helps to: (1) eliminate password reuse; (2) increase password length and strength; (3) raise the number of accounts protected with 2FA or passkeys; and (4)

keep everyday sign-in convenient and efficient.

We proposed a short user guide: create a strong master passphrase using several random words, enable two-step verification for the password manager, import saved passwords from the browser, replace reused items with automatically generated long passwords, enable breach alerts, and store recovery codes securely. For high-value accounts (email, banking, learning platforms), we additionally recommended enabling 2FA or passkeys. The effect was measured with simple indicators: the number of remaining reused passwords, the average password length, how many accounts received 2FA protection, and whether daily sign-in time changed. Data came from the manager's built-in reports (e.g., "weak/reused" flags) and a brief before/after survey.

After switching to a password manager, most users stopped reusing the same password; the average length of newly created passwords increased due to automatic generation; and more essential services were protected with 2FA or passkeys, significantly reducing the risk of phishing. Users reported that, after the initial setup, sign-in did not take longer – autofill actually saved time. The most common mistakes included storing the master passphrase in note-taking apps, ignoring recovery codes, and sharing a single login among multiple people. These issues were addressed with simple rules: avoid storing the master passphrase in plain text, keep recovery codes offline, and use shared vaults with permissions instead of shared credentials.

A password manager is a practical everyday security tool: it eliminates routine work, prevents password reuse, encourages stronger passwords, and simplifies the adoption of 2FA and passkeys. A short checklist (master passphrase, recovery codes, replacing reused passwords, breach checks) noticeably raises the basic security level without complex configuration. In schools and small organizations, this is enough to significantly reduce common account incidents. Next steps include periodic self-audits in the password manager and regular reminders to enable 2FA for new services.

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ANALYSIS OF METHODS FOR ACCESS AND RESOURCE MANAGEMENT IN ELECTRONIC COMMUNICATION NETWORKS

When developing modern electronic communication networks, an important task is to ensure guaranteed quality of service for users despite limited communication channel bandwidth. Quality of Service (QoS) is defined as a cumulative indicator of network performance that reflects the degree of user satisfaction with the service. In practice, QoS depends both on the technical parameters of the network and on the user's perception of the service, which emphasises its dual technical and subjective nature. In networks, QoS indicators are assessed based on parameters such as average transmission delay, delay variation, packet loss rate, and throughput. These characteristics determine the effectiveness of real-time services such as video conferencing, streaming audio, and VoIP. To maintain stable QoS values, traffic classification and marking methods, packet queuing mechanisms, and prioritisation of critical data flows are used. To ensure QoS in networks with intense and variable traffic, bandwidth allocation modes are used, including CBR, VBR, ABR, and UBR. CBR mode provides fixed bandwidth and minimum delays, whereas RT-VBR and NRT-VBR modes allow variable speeds for different delivery time requirements. ABR mode provides dynamic allocation of available bandwidth depending on the current network load. In addition to bandwidth allocation, it is important to ensure effective management of network resources at the access level. Management systems use monitoring, routing, and load balancing mechanisms to optimise channel performance in variable traffic conditions. At the hardware level, this is implemented using specialised switches and routers with QoS policy support, and at the software level, through centralised network management controllers.

Managing access to network resources is a critical element of maintaining network stability. Large infrastructures use authentication, authorisation, and accounting (AAA) algorithms to centrally control user and administrator access, prevent unauthorised access, and ensure network scalability. The most common implementations of AAA systems include the RADIUS and TACACS+ protocols, which provide centralised user authentication, access rights control, and administrator activity logging. In addition, IEEE 802.1X technology is widely used to enhance security when connecting to a local network, integrating user verification procedures directly at the network level. This approach allows you to effectively combine security mechanisms with quality of service control. Using an access control system such as Cisco Secure ACS allows you to combine access and identification policies, increasing network reliability and manageability.

To improve the efficiency of electronic communication networks, it is necessary to apply adaptive methods of access and resource management that ensure stable QoS indicators. It has been shown that the use of traffic prioritisation mechanisms, dynamic bandwidth changes and AAA systems can reduce delays, avoid overloads and maintain service reliability. The proposed approaches can be implemented in the form of software and hardware solutions and integrated into modern electronic communication systems to increase network flexibility and performance. The combination of adaptive control methods with QoS systems and AAA procedures allows for network status prediction and resource allocation optimisation in dynamic load conditions.

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SECTION 5. ENERGY EFFICIENCY

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HCPV THERMAL RISKS AND THEIR ENGINEERING SOLUTIONS

Growing global demand for energy is driving the development of high-concentration photovoltaic (HCPV) technologies. Although light concentration allows for significant power increases, it also causes significant heat generation, which becomes a critical limiting factor. Overheating leads to a decrease in open-circuit voltage, a drop in efficiency, and accelerated material degradation (microcracks, contact destruction, PID effect), limiting the practical application of concentrations above 200×. An effective solution to this problem requires not just heat dissipation, but precision thermal management at the micro and macro levels.

Overheating in HCPV is multi-level in nature:

Macroscopic irregularity: Stationary, continuous liquid cooling methods lead to an uneven temperature field due to overcooling of the input zone and insufficient cooling of the output zone.

Microscopic hot spots: The most destructive is localised heat generation within a single cell caused by uneven light absorption, charge carrier recombination and reverse bias effects under partial shading. Modelling confirms that in HCPV (1000×), internal hot spots can cause temperature differences of up to 169 K, which critically reduces the service life.

A detailed study of partial shading shows that the unshaded part of the cell enters an energy consumption mode and forms a hot spot that can be approximately 20–25 °C warmer than the rest of the surface. This means that effective thermal management must take into account not only average temperatures but also rapid local changes.

To ensure uniform and efficient heat dissipation, we propose applying the concept of a Multi-Adaptive Thermoelectric System (MATS), which combines two key approaches:

Dynamic cooling with a pulsating flow. Pulsating flow breaks down the wall-boundary thermal boundary layer, which increases the heat transfer coefficient. Studies confirm that this mode can increase the thermal efficiency of the system by approximately 10–25% compared to steady flow. The main problem is the vibrations of the pulsating pump, which must be compensated for by means of an optimised design or active damping.

Adaptive control based on microdiagnostics. It is proposed to integrate microelectrical sensors into potentially risky areas of the photovoltaic cell. This allows real-time adjustment of the frequency and amplitude of pulsation, directing cooling resources to areas where hot spots form. This approach makes it possible to respond to rapid changes in insolation, shading, or internal defects.

So, MATS can significantly improve the stability and efficiency of HCPV systems while eliminating macro- and micro-level overheating problems. The main engineering challenge remains the development of an active vibration damping system in pulsating pumps and the optimisation of control algorithms under variable insolation conditions.

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ENERGY EFFICIENCY IN HORTICULTURE AND FRUIT AND VEGETABLE GROWING: MODERN APPROACHES AND RESEARCH RESULTS

It should be noted that energy does not come from nowhere – in Ukraine, it is mainly produced from fossil fuels. Before Russia's full-scale invasion, half of the electricity was supplied by nuclear power plants, which produce tonnes of radioactive waste during operation. Another third and most of the heat for heating is the result of burning fossil fuels, which pollutes the air and exacerbates climate change. Therefore, the less energy we consume, the less damage we cause to the environment and the easier it will be to gradually replace dirty fuels with cleaner and safer renewable energy sources (sun, wind, biomass, etc.).

The energy efficiency is one of the key factors of competitiveness in agricultural production, particularly in horticulture and fruit and vegetable growing. Intensive crop cultivation technologies require significant energy resources: electricity, heat, fuel for machinery, and water resources for irrigation. In the current context of rising energy costs and the need for environmental sustainability, the introduction of energy-saving technologies is becoming particularly relevant.

The energy efficiency of horticulture refers to the ratio of the energy contained in the grown produce to the total energy used in the production process. It is an indicator of how ‘usefully’ energy is spent, as opposed to simple energy conservation, and covers aspects such as optimising resource use, reducing energy costs at all stages (from planting to harvesting) and increasing overall productivity.

In traditional horticulture systems, energy costs for heating greenhouse complexes account for 50–70% of total energy consumption, which negatively affects the cost of production. A significant portion of energy is also spent on irrigation, spraying, and post-harvest fruit processing systems.

Ukraine, with its strong potential for fruit and vegetable production, also faces challenges: outdated cultivation technologies, low levels of automation, and limited use of renewable energy sources.

There is a growing trend towards the creation of agricultural enterprises' own processing facilities and processing workshops based on mini-equipment, which in principle cannot compete in terms of efficiency with modern powerful processing enterprises.

The operation of their own fruit and vegetable processing facilities has led to the introduction of payment in kind for farm workers, not only with fresh fruit and berries, but also with canned products (juices, jams, preserves, canned vegetables, etc.). As a result, the market for finished (processed) products has seen the emergence of private horticultural farms alongside traditional sellers.

Among the perspective areas of energy efficiency in horticulture, the following can be highlighted: integration of renewable energy sources (solar panels, biogas plants); introduction of smart greenhouse management using sensors and artificial intelligence; energy-saving post-harvest technologies: ozonation, vacuum cooling; optimisation of logistics processes and fruit storage. The implementation of these solutions will reduce the burden on the environment, improve product quality and ensure the stability of enterprises in the industry.

The efficient use of energy resources is the basis for the sustainable development of horticulture in Ukraine. The study confirmed that the introduction of energy-saving technologies significantly reduces energy consumption, increases yields and economic benefits. Further scientific and industrial developments in this area will contribute to the formation of a competitive and environmentally oriented market for fruit and vegetable products.

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ACHIEVEMENTS, CHALLENGES AND PROSPECTS OF ENGINEERING

Engineering is one of the most important areas of human progress — it connects science, creativity, and technology to solve a wide range of problems. In the last 100 years, engineers have created the basics of today's world: electricity, transportation networks, computers, satellites, and green energy systems. The National Academy of Engineering reports inventions like Internet, medical imaging, and clean water systems have made life better for billions of people. Engineering has also played a crucial role in developing clean technologies, artificial intelligence, and space exploration. For example, the success of SpaceX`s reusable rockets, the fast growth of solar and wind energy, and new inventions in biomedical engineering like robotic prosthetics show how the power of modern engineering can shape our future.

But these successes come with big challenges. One of the main issues is how fast technology is changing. Engineers have to keep learning new materials, digital tools, and production methods. Automation and AI are changing industries, so professionals need to mix traditional technical skills with new ones like programming, data analysis, and systems thinking. Education systems often struggle to keep up with these changes, which creates a gap between academic training and practical needs in industry.

Another big challenge is sustainability. Industrial growth and technological expansion have led to climate change, pollution, and resource depletion. Engineers now face the dual responsibility of creating innovation while minimizing harm to the planet. Green engineering and recycling ideas are now important in many areas - from building and manufacturing to energy and transport. But making these changes requires a lot of money, international cooperation, and updated environmental regulations.

Looking ahead, the future of engineering is full of exciting possibilities. New areas like nanotechnology, biotechnology, quantum computing, and renewable energy will change human possibilities. Engineers will lead in making smart cities, creating eco-friendly technologies, and providing clean water and sustainable infrastructure for everyone. Education will evolve toward interdisciplinary programs combining engineering, environmental science, and digital innovation. Learning throughout life, being creative, and working together across borders will become the new norm.

In conclusion, engineering keeps moving the world forward and helps solve the most complex problems we face. Its achievements have changed the way we live, its challenges urge us to think responsibly, and its future offers endless opportunities for innovation.

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ENERGY STORAGE SYSTEMS AS A VITAL COMPONENT FOR A SUSTAINABLE ENERGY FUTURE

The way we produce electricity is undergoing a fundamental transformation globally, and this is especially true for countries like Ukraine that are striving for energy independence and sustainability. We are progressively moving away from traditional fossil fuels like coal and natural gas and towards renewable sources such as solar panels and wind turbines. These renewable sources are clean, produce no harmful emissions, and are better for our environment. However, they come with a significant challenge: their energy production is intermittent and unpredictable. The sun does not shine at night, and

wind speeds are constantly changing. This creates a major problem for grid operators who must always balance the amount of electricity being generated with the amount consumers are using. If this balance is lost, it can lead to blackouts or damage to equipment. This is precisely where Energy Storage Systems (ESS), become an absolutely vital component. For a future powered by clean and reliable energy, we need sophisticated systems that can store excess electricity when production is high and release it back into the grid when demand peaks or generation drops.

ESS can be thought of as giant, grid-scale batteries. Their primary function is to capture electrical energy, store it efficiently for a period of time, and then discharge it upon command. The most widely recognised type today is large-scale battery energy storage, which often uses lithium-ion technology, similar to the batteries in our laptops and electric vehicles, but on a much larger and more complex scale. Pumped hydroelectric storage is the most common form of energy storage in the world; it works by pumping water from a lower reservoir to an upper reservoir when there is excess electricity, and then releasing it through turbines to generate power when it is needed. Other emerging technologies include flywheels, which store energy as rotational motion, and compressed air energy storage, which pumps air into underground caverns under pressure.

Let us consider a modern household with rooftop solar panels. During a sunny afternoon, the solar panels may produce more electricity than the home is using. Without a battery, this surplus power is fed back into the local grid. While this is beneficial, the homeowner remains dependent on the grid at night. With a home battery system, like the Tesla Powerwall or similar products, that excess solar energy is stored locally. Then, after the sun sets, the household can draw electricity from its own battery, significantly reducing its reliance on the grid and saving money. This exact same principle applies to utility-scale storage, but it supports entire neighbourhoods, cities, and even the national energy system.

In conclusion, ESS are far more than just a helpful accessory for the modern power grid; they are a foundational pillar for a sustainable, resilient, and secure energy future. They provide the critical link that allows us to maximise the use of clean, renewable energy sources by making their power available on demand, day or night. This capability is crucial for nations aiming to enhance their energy independence and reduce their carbon footprint. For students of electrical engineering, this field represents a dynamic and rapidly growing area full of opportunity, offering the chance to design, build, and manage the technologies that will form the backbone of our clean energy infrastructure for decades to come.

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SECTION 6.
ECOLOGICAL SAFETY

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FORMULA 1 AS A TECHNOLOGY ACCELERATOR: EVALUATING THE VIABILITY OF SUSTAINABLE E-FUELS FOR GLOBAL TRANSPORT

From the inception of Formula 1 (F1) racing, the usage of petroleum-based fuels has represented a critical environmental concern. The annual racing calendar, combined with the ongoing emissions of exhaust gases, exacerbates the greenhouse effect. Hence, this may pose some notorious negative consequences not only for global air quality but also for specific ecosystems and species – such as polar bears, whose survival strongly relies on climate stability.

Due to increased environmental awareness in society, F1 organizers and stakeholders have committed to a full transition to 100% sustainable fuels for the 2026 season. The underlying concept behind sustainable fuel is carbon neutrality, meaning the amount of carbon released into the atmosphere during combustion is equal to the amount of carbon absorbed from the atmosphere during the fuel's production lifecycle.

The true significance of this shift transcends F1's own small fraction of global emissions. Instead, F1 is positioning itself as a technology accelerator, leveraging its rapid development cycle and competitive engineering environment to refine and scale synthetic e-fuels (power-to-liquid). Given that billions of Internal Combustion Engine (ICE) vehicles will remain on the world's roads for decades, it is crucial to evaluate the technical and economic viability of F1's sustainable fuel – designed to be a "drop-in" replacement – as a predominant, non-electrification pathway for global transport decarbonization.

Unlike first-generation biofuels competing with food production for arable land, e-fuels are synthesized using captured carbon dioxide (often direct air capture or industrial sources) and green hydrogen, which is produced via electrolysis powered by renewable electricity (wind, solar). Through the Fischer-Tropsch process, H_2 and CO_2 are chemically combined to form a synthetic hydrocarbon that is molecularly identical to fossil fuel components. Because this synthetic fuel can be "dropped in" to existing infrastructure and current Internal Combustion Engines (ICEs), it offers a viable path to decarbonize vehicles already on the road, bypassing the immense cost and time of a full, immediate global electrification mandate. While the technical concept is sound, the viability of e-fuels for mass market application hinges on two major hurdles that F1's development must help solve: energy efficiency and infrastructure. Regarding the first point, the entire PtL process is highly energy-intensive, requiring vast amounts of renewable electricity to produce the hydrogen. The biggest challenge is ensuring that this energy conversion is efficient enough to make the fuel cost-competitive with traditional gasoline on a large scale. F1's competitive pressure drives immediate improvements in process efficiency that can be scaled up. As for the second one, to deliver true carbon neutrality, the entire process must operate on renewable energy – a guarantee F1's partners are obligated to meet. F1 is therefore acting as the premium customer, pulling the market and forcing the creation of the necessary sustainable supply chain infrastructure, from specialized electrolysis plants to advanced CO_2 capture facilities.

Ultimately, the significance of F1's fuel transition transcends the racetrack. The sport's low-volume, high-value demand serves as a crucial de-risking mechanism for the emerging (nascent?) e-fuel industry. By validating these energy sources under the most strenuous, high-performance conditions, F1 proves their reliability, energy density, and technical readiness for deployment. The benefit is outstanding: for the billions of vehicles that will rely on liquid fuels for decades, F1's sustainable fuel offers a proven, non-disruptive route to achieving net-zero emissions. The legacy of F1 may shift from a symbol of combustion power to a catalyst for environmental sustainability, accelerating a critical solution for global transport decarbonization.

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ORGANIC FARMING PRACTICES

Organic agriculture is a production system that regenerates the health of soils, ecosystems, and people. Organic farmers rely on natural processes, biodiversity, and cycles adapted to local conditions rather than the use of synthetic inputs like chemical fertilizers, pesticides, and herbicides. GMOs are not allowed in organic. Organic farming relies on natural principles like biodiversity and composting instead to produce healthy, abundant food.

Organic farmers apply techniques first used thousands of years ago, such as crop rotations and the use of composted animal manures and green manure crops, in ways that are economically sustainable in today's world. Organic producers implement a wide range of strategies to develop and maintain biological diversity and replenish soil fertility.

Organic farming works in harmony with nature. Since organic farmers don't use synthetic fertilizers, GMOs, or pesticides, they have to fight insects, disease and weeds and grow abundant food with the help of other methods. What connects all organic farming practices is their ultimate goal: to build and improve the soil, quite literally the foundation of our food system and our lives.

Healthy soil is that which allows plants to grow to their maximum productivity without disease or pests and without a need for off-farm supplements. Healthy soil is teeming with bacteria, fungi, algae, protozoa, nematodes, and other tiny creatures. Those organisms play an important role in plant health. Soil bacteria produce natural antibiotics that help plants resist disease. Fungi assist plants in absorbing water and nutrients. Together, these bacteria and fungi are known as "organic matter." The more organic matter in a sample of soil, the healthier that soil is.

Healthy soil contains aggregates that help it bind together, preventing erosion and run-off. It can hold more water, so plants fare better in drought. It contains more bacteria and fungi that help plants fight diseases and pests. And healthy soil also contains more minerals and nutrients that feed plants. Healthy soil is the foundation of our global food system, but currently, it's at risk. Every organic farming practice contributes to healthy, resilient soil that can support abundant life both below and above ground, making organic farming a powerful tool for soil conservation.

Cover crops primary job is to improve the soil. They get planted in fields that would otherwise be bare-in between growing seasons, for example — to protect the soil from erosion and nutrient loss. Cover crops also help smother weeds, control pests and diseases, enhance water availability, and increase biodiversity on the farm. Every time a farmer grows her cash crop, the plants draw nutrients out of the soil. After the harvest, those nutrients need to be returned so that the next crop is equally bountiful.

Certain cover crops have the unique ability to "fix" nutrients like nitrogen from the atmosphere and return them to the soil, making them an indispensable tool in maintaining and increasing soil fertility without chemical use. Cover crops are an integral part of organic no-till.

Conventional farmers rely on synthetic fertilizers and chemical herbicides to return nutrients to their soils and fight weeds. Those methods have a host of unintended consequences, including water pollution, soil erosion, and loss of essential biodiversity, among others. Since synthetic inputs aren't allowed in organic agriculture, organic farmers rely on other methods, including cover cropping, to achieve the same results.

As for crop rotation, it is the practice of planting different crops sequentially on the same plot of land to improve soil health, optimize nutrients in the soil, and combat pest and weed pressure. A simple rotation might involve two or three crops, and complex rotations might incorporate a dozen or more. Different plants have different nutritional needs and are susceptible to different pathogens and pests.

If a farmer plants the exact same crop in the same place every year, as is common in conventional farming, she continually draws the same nutrients out of the soil. Pests and diseases happily make themselves a permanent home as their preferred food source is guaranteed. With monocultures like these, increasing levels of chemical fertilizers and pesticides become necessary to keep yields high while keeping bugs and disease at bay. Crop rotation helps return nutrients to the soil without synthetic inputs.

The practice also works to interrupt pest and disease cycles, improve soil health by increasing biomass from different crops' root structures, and increase biodiversity on the farm.

Compost is created from the aerobic decomposition of many materials usually considered waste, including food scraps, animal manures, leaves, straw, and more. Composting occurs when carbon-rich materials ("browns"), like straw and leaves, are mixed with nitrogen-rich materials ("greens"), like food scraps and manure. Add oxygen, time, some skilled management, and the help of billions of microorganisms. The finished result is crumbly, sweet-smelling, and nutrient-packed compost.

Conventional farmers rely on synthetic fertilizers made from fossil fuel-intensive petroleum that can pollute local water supplies and harm wildlife. Organic farmers rely on inputs like compost instead. Not only does compost drastically reduce an organic farmer's need for chemical inputs, but the process of creating compost recycles farm materials, too. When incorporated into the soil, compost provides a diversity of microorganisms and nutrients that encourage healthy plant growth and development.

Tillage is the practice of digging up, turning over, or otherwise agitating the soil with mechanical tools — typically a plow or disc. Tilling breaks up soil compaction, helps eliminate weeds, and incorporates cover crops for boosted soil fertility. These are important benefits, but tillage also leaves soil vulnerable to erosion and destroys important fungal networks underground. Tillage is also fuel- and labor-intensive. In conventional systems, farmers can practice no-till by using chemical herbicides to kill cover crops before the next planting. Organic no-till, on the other hand, uses no synthetic inputs.

Bugs and insects are a given on any farm. Some bugs are beneficial — they prey on the bad bugs and provide valuable pollination. But other insects pose a threat. Pests can damage the appearance of fruits and vegetables, making those products difficult or impossible to sell. Even worse, some pest damage can kill a crop outright. Conventional farmers spray toxic pesticides to eliminate pests. Organic farmers use alternative strategies to reduce and control pests without the use of synthetic inputs.

The first line of defense is prevention. Healthy soil creates strong plants that are resilient to pest pressure. Other strategies include rotating crops and selecting pest-resistant varieties of crops. When pests become a more serious problem, organic farmers might use pheromones to disturb pest mating cycles, or mechanical controls like trapping. When all other methods have been exhausted and a farmer is faced with a potential significant loss, targeted sprays of organic-approved pesticides may be used.

Chemical pesticides pollute our air and water. They kill good bugs and insects, too, destroying biodiversity in a way that has a ripple effect on ecosystems throughout the farm. Organic farmers implement many strategies, including those detailed above, to reduce the use and consequences of chemical pesticides and promote a farm system that works in harmony with nature. The result is reduced cost, stronger plants, healthier wildlife, and a cleaner environment for everyone.

Ukraine has a large and growing organic agriculture sector, ranked 20th globally, with over 400,000 hectares of certified land dedicated primarily to organic cereals, legumes, and oilseeds. The government supports this sector through its National Economic Strategy 2030, which aims to increase organic land to 3% of total agricultural land and grow organic exports to \$1 billion by 2030. Despite challenges like heavy reliance on grain crops and reduced domestic sales in 2022, the sector has shown resilience, particularly in processing organic products, and continues to supply both domestic and international markets.

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ENVIRONMENTALLY RESPONSIBLE ENGINEERING ISSUES

Over the past decades, engineering science has achieved significant progress in automation, mechanical engineering, electronics, bioengineering, and energy sectors. However, this progress has also led to increased energy consumption, waste accumulation, and pollution. Many industrial enterprises continue to use outdated technologies that do not meet modern environmental standards.

One of the most pressing challenges of modern engineering is environmental pollution caused by industrial processes. The metallurgical, chemical, energy, and transport industries generate millions of

tons of harmful substances every year. In Ukraine, industrial regions such as Zaporizhzhia, Dnipropetrovsk, and Donbas remain among the most polluted areas. Uncontrolled resource extraction has led to the depletion of mineral deposits and the formation of technogenic wastelands. Open-pit mining and toxic discharges into rivers are direct consequences of industrial activity lacking proper environmental control.

Another major issue is deforestation, closely tied to industrial demand. Forests, which play a crucial role in climate regulation and oxygen production, are being destroyed at rates far exceeding their natural recovery. Unregistered forests without official protection suffer the most from logging, pests, and fires. Between 2021 and 2023, new forest plantations were created in Ukraine, but many of them appeared not on degraded lands, as expected, but on valuable natural landscapes such as steppe ravines and open terrains. Ecologists emphasize that tree planting should focus primarily on the reclamation of quarries, spoil heaps, and territories affected by war or industrial exploitation.

Another key problem is the inefficient and wasteful use of natural resources. Humanity consumes more than nature can restore. Energy, water, forest, and land resources are being exploited beyond sustainable limits, largely due to poor management and the absence of an integrated approach to resource conservation. A notable example of environmentally conscious engineering is the French company Neo-Eco, which applies the principles of the circular economy. In its Ukrainian project in Hostomel, all materials from demolished buildings were carefully sorted and reused wherever possible. Non-recyclable components were processed by licensed recycling companies and transformed into new materials or energy. This project demonstrates how responsible engineering can minimize environmental harm while supporting reconstruction efforts.

The future of engineering lies in responsibility, sustainable design, and the application of technologies that serve both society and nature. Combining scientific progress with ecological principles is the only path to achieving sustainable development, where technological advancement no longer threatens the preservation of life on Earth.

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ENVIRONMENTAL SECURITY IN THE CONDITIONS OF MARTIAL LAW

Environmental security is one of the key aspects of Ukraine's national security, especially under martial law. Military actions cause irreparable damage to the environment, causing soil, water and air pollution, destruction of natural ecosystems, and also creating the threat of man-made and radiation disasters. In this connection, the question arises regarding effective legal regulation and ensuring environmental safety during the crisis period. Ensuring environmental safety is the main way to solve environmental problems [1].

For the fourth year, the RF have been shelling Ukrainian territories, which means they are poisoning our lands with dangerous chemicals, disrupting entire ecosystems. Many areas are covered with craters after shelling and are not suitable for agricultural use due to the large amount of chemicals contained in the ammunition. Rocket attacks and bombings cause huge forest fires. According to ecologists, 50 tons of toxic emissions were released into the air due to fires in forests, cities, and oil depots that the Russians bombarded at the beginning of the full-scale war.

Recently, Russian forces have been attacking critical and industrial infrastructure facilities, causing additional air, soil and water pollution. As a result, toxic gases enter the air, it becomes difficult for people to breathe and the soil is polluted with dangerous substances.

The largest event was when the RF occupying forces blowing up the dam of the Kakhovskaya HPP. Its destruction caused a catastrophic flood and flooding of the lower Dnieper. About 330 hectares of nature conservation lands were in the flooding zone. The left bank of the region, which remained under Russian occupation, was flooded the most. In some cities, the water level reached five meters As a result, a large number of people suffered, the water destroyed their houses, and caused irreparable damage to the natural reserve fund of the region.There was a mass death of fish, damage to flora and fauna. According to the estimates of the nature protection group, 70% of the fauna of the reservoir was affected. The devastation of the reservoir lasted 20 days. The explosion of the Kakhovskaya HPP and the flooding of the territories in the future will have significant consequences for people and the environment. In particular, we already have existing problems with water supply in nearby settlements. After all, the Kakhov reservoir supplied water to cities, villages, and industrial facilities. After the detonation, 850,000 people were left without water. The explosion of the Kakhovskaya HPP and the flooding of territories will have significant consequences for people and the environment in the future. In particular, we already have existing problems with water supply in nearby settlements [2].

As a result of the aggressive actions of the Russian troops, there was a radiation threat to the security of Ukraine. Currently, the Zaporizhzhia nuclear power plant, which is under occupation, is experiencing a critical situation. And any accident can lead to dire consequences.

To this day, the aggressor country ignores the consequences of its own actions, which cause the scale of the ecological disaster, which is a threat not only to Ukraine, but also to the whole of Europe. According to experts, the minimum estimate of environmental damage during the year of the war is 441 billion dollars. This figure should be impressive, because the current war is an unprecedented case of damage to the Ukrainian environment. As long as hostilities continue, both the population and the environment remain at risk.

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ENVIRONMENTAL SAFETY DURING ENGINEERING AND GEOLOGICAL EXAMINATIONS FOR CONSTRUCTION

Engineering and geological examinations (surveys) are fundamental stages preceding any construction project. Their primary goal is to assess the geological, geotechnical, and hydrogeological conditions of a site to ensure the proposed structure's stability, reliability, and durability. Crucially, these examinations must be conducted with strict adherence to environmental safety principles to prevent irreversible damage to the natural environment and safeguard public health.

The core principle of environmental safety in these surveys is the comprehensive assessment and minimization of the ecological footprint associated with exploratory drilling, geophysical methods, and laboratory testing.

The Role of Geo-Environmental Surveys and International Standards

Modern practice emphasizes geo-environmental surveys, which move beyond traditional geotechnical assessments to specifically investigate environmental aspects of the land. These surveys are essential for:

1. Identifying Environmental Risks: Detecting potential hazards such as soil and groundwater contamination (often from previous industrial use), the presence of hazardous materials, or natural risks like unstable geological conditions, gas emissions, or potential flooding.

2. Ensuring Compliance: Guaranteeing that the project and its investigative phase comply with national environmental legislation.

Environmental Safety in Ukraine

In Ukraine, environmental safety during construction-related geological examinations is regulated by a hierarchy of legislative acts and state building codes. A cornerstone of this regulation is the Law of Ukraine "On Environmental Impact Assessment" (EIA). While the law primarily focuses on the planned construction activity itself, its principles extend to the necessary preparatory work. Projects that have a significant impact on the environment must undergo a rigorous EIA process, which inherently relies on data gathered during geological and environmental surveys.

Furthermore, the Code of Ukraine on Subsoil and specific State Building Norms (DBN) outline the requirements for conducting engineering and geological surveys, emphasizing that design – which is based on survey results – must be carried out considering environmental safety requirements. Key Ukrainian regulatory principles include:

- Integrated Design: Designing structures and protection measures based on geological and other subsoil studies, while considering environmental safety;
- Mitigation of Processes: Planning organizational and technical measures to weaken the harmful effects of dangerous geological processes (e.g., landslides, karst) identified during the surveys, thereby reducing potential damage and threat to human life;
- Self-Regulation: Implementing principles that maximize the ability of natural systems to self-regulate and self-restore after the completion of the survey work.

Conclusion

By meticulously integrating environmental management principles, adhering to national standards, and regulations, engineers and geologists can ensure that the preparatory phases of construction not only secure the future structure but also protect the geological environment – a vital, non-renewable asset – for the community. This holistic approach is the definitive marker of sustainable and responsible engineering.

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DEVELOPMENT OF ENVIRONMENTALLY FRIENDLY PACKAGING FOR FRUIT AND BERRY JAMS

Packaging is crucial in ensuring the quality and safety of food protecting it from various contaminants, and extending its shelf life. Materials used for packaging food must be economical, durable, and possess good barrier properties. One of the major challenges faced by the food industry is developing an eco-friendly, economical, and sustainable packaging system. The packaging of food is essential to guarantee the quality and safety of food since it shields food from contamination, dust, temperature, mechanical damage, light, and humidity, increasing its shelf life and reducing food waste.

Canned goods are a valuable food product because they almost completely retain their taste and aroma, and, when properly prepared, also preserve vitamin C. As for jam, it is a product made from fruits cooked in sugar syrup, with or without the addition of pectin, organic acids, or spices. The finished jam

has a jelly-like consistency of sugar syrup, in which whole or chopped, pre-prepared fruits are evenly distributed. Fruit and berry jams are highly beneficial for the body as they contain vitamins C, E, and B-complex, as well as minerals such as potassium, magnesium, and iron. These nutrients help strengthen the immune system and improve digestion. Thanks to their antioxidant properties, jams can positively affect the condition of skin, hair, and nails, and also support cardiovascular health.

The most beneficial jams are considered to be raspberry, blackcurrant, and rosehip jams. Raspberry jam helps with colds, reduces high temperature, and soothes a sore throat. Blackcurrant jam is regarded as the most beneficial due to its high vitamin C content, which strengthens immunity. Rosehip jam contains vitamin C and antioxidants, which not only boost the immune system but also protect cells from oxidation. This type of jam can be considered rejuvenating, as its antioxidants promote collagen production, making the skin firmer and more elastic.When choosing a product, it is advisable to prefer natural jams with low sugar content and no artificial additives.

Environmentally safe packaging for jams plays an important role in protecting the environment. Eco-friendly packaging can include recycled glass jars and metal cans, which are easily recyclable. Other options are compostable pouches made from plant-based materials or bioplastics. For labels, biodegradable or seed paper labels can be used, which can be planted, and for outer packaging, cardboard or recycled cardboard is recommended.

There some main kinds of environmentally safe packaging:

- Recycled glass jars: glass can be endlessly recycled without loss of quality, and consumers are familiar with recycling it.
- Metal cans: steel cans are highly recyclable and provide excellent protection for the jam.
- Compostable pouches: made from plant materials, they naturally break down.
- Bioplastics: made from renewable resources, they are biodegradable and recyclable.
- Biodegradable labels: made from materials such as sugarcane waste or hemp, they can fully decompose.
- Seed paper labels: a creative option where customers can plant the label to grow wildflowers.
- Cardboard and kraft paper: these materials are widely recyclable and biodegradable.
- Molded pulp packaging: a good option for protecting glass jars.
- Minimalist packaging: reducing the amount of material used is an effective eco-friendly strategy.

Environmental awareness is an important aspect of modern life, involving a conscious attitude toward nature and responsibility for one’s actions. Being environmentally aware means caring for the conservation of natural resources, reducing waste, avoiding excessive consumption, and choosing products that do not harm the environment. Every small step—sorting waste, reusing items, choosing eco-friendly packaging, or avoiding plastic—contributes to preserving the planet for future generations. Developing an ecological culture is not only a personal responsibility but also a societal one, as the state of the environment depends on our habits.

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SUSTAINABLE APPROACHES TO VEGETABLE CANNING BY-PRODUCTS

Preservation of biologically valuable vegetable raw materials not only extends their storage life, but also significantly reduces the labour and time required to prepare food at home. It allows restaurants to diversify their menus and provide customers with high-quolity products throughout the year. Thanks to the active implementation of standards, technical conditions and the improvement of technical and microbiological control, the quality of canned products is constantly improving. Particular attention is paid to improving production technology, using more sophisticated equipment, expanding the product range and improving the biological value and taste qualities of canned products.

Vegetable conservation holds a leading position in the canning industry in Ukraine and abroad. However, waste from the production of canned goods has a wide range of uses. For example, when

processing tomatoes into tomato puree or tomato paste, they are washed, inspected and crushed, so the first waste occurs during the inspection of raw materials; rotten, mouldy or pest- and disease-infested tomatoes are discarded. When tomato pulp is rubbed, waste is formed in the form of a mixture of peel and seeds (3.5-4.0%), which can be used as fodder for domestic animals [1]. The most common waste produced in the production of tomato oil is soapstock (produced after oil refining).

Soapstock is a waste product formed as a result of refining fats and oils in alkaline solutions. It consists of neutral fats, bound fatty acids, soap, water, various mucus, proteins, salts, dyes and other substances. This composition makes the soap mass suitable for the production of fatty acid esters – mixtures of methyl and/or ethyl monoalkyl esters of long-chain fatty acids (saturated and unsaturated), which are raw materials for environmentally friendly biofuel – biodiesel. In recent years, many European countries (e.g. Germany, Austria, Italy and France) have increased their production of fuel from renewable raw materials. Most of these raw materials are low-quality rapeseed oil and sunflower oil. Since the cultivation of these crops leads to soil depletion, preference is given to the use of waste from certain industries, in particular canning [2].

A separate issue in the disposal of canning industry waste is water purification. The food industry ranks first in terms of water consumption per unit of product manufactured. Canning factories use more water than is needed to process raw materials: 5–7 m3 of water is needed to process 1 tonne of fruit and vegetables. The wastewater itself is often non-toxic, but once it enters water bodies, its high organic residue content can promote the growth of bacteria, which can very quickly deplete the oxygen necessary for the life of other organisms [3]. Therefore, the issue of constructing treatment facilities alongside canning production must be resolved during the design phase of the plant.

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ENVIRONMENTAL SECURITY AS A COMPONENT OF NATIONAL SECURITY AND A GUARANTEE OF SUSTAINABLE DEVELOPMENT

Ecological security is a state of nature when the environment does not undergo dangerous changes, and people's lives and health are not threatened. It is the basis of national security, since without a protected natural environment, stable development of the state and the well-being of the population are impossible. It is absolutely clear, especially now during the russian full-scale invasion of Ukraine. For example, over 3 million hectares of forests have been damaged or destroyed during the war, about 1.2 million tonnes of pollutants have been released into the air, about 30% of Ukraine's land is estimated to be contaminated with landmines or unexploded ordnance, flora and fauna suffer due to deforestation, habitat fragmentation, pollution, and direct destruction, etc. According to some estimates, Ukraine needs $524 billion over the next decade for post-war reconstruction including not only infrastructure, but also environmental recovery.

The system of ensuring ecological security includes legislative norms, economic mechanisms, technological solutions and organizational measures aimed at reducing pollution, rational use of resources and prevention of harmful consequences for nature. All these actions are coordinated by the

state through programs, strategies and special control bodies.

The essence of ecological security is to create conditions under which ecosystems remain stable and natural resources are not depleted. It covers various scales - from local natural objects to the global biosphere, because any negative impact on nature can have long-term and large-scale consequences. Important components of ecological security include environmentally friendly production, monitoring the condition of soils, water and air, the use of clean technologies and compliance with international standards. The objects of its protection are humans, natural resources and the environment as a whole.

The main principles of ensuring environmental safety include the priority of protecting nature and humans, the availability of environmental information, responsibility for environmental damage, the balanced use of resources and taking into account the interests of future generations. Environmental safety is the basis of sustainable development: it allows preserving natural resources, minimizing the negative impact of human activity and creating safe living conditions for present and future generations.

Environmental security is not just a set of laws, norms, or government programs. It is, first of all, the realization that people's health, the stability of the state, and the future of new generations are inextricably linked to the state in which we leave nature. We want to convey that a responsible attitude to the environment is not the choice of individual enthusiasts, but the common duty of each of us. Today, any of our actions, even the smallest, becomes part of a large impact on the Earth ecosystems. We cannot afford indifference, because every manifestation of pollution, depletion of resources, or disregard for nature returns to people in the form of diseases, disasters, and loss of life opportunities.

Therefore, the main meaning of environmental security is to learn to live in such a way that development does not destroy the foundation of our lives. We would like to emphasize: environmental protection is an investment in our health, well-being, and a peaceful tomorrow. Only a conscious, responsible, and united position of society can guarantee that we will pass on to future generations not a depleted planet, but a safe, harmonious, and life-giving world.

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ENVIRONMENTAL SAFETY: ENVIRONMENTAL POLLUTION AND ITS IMPACT ON HUMAN HEALTH

In our time, environmental pollution has become one of the biggest problems for people all over the world. Because of fast industrial development, growing cities and intensive farming nature is seriously suffering. Every day factories, cars and other sources release harmful substances into the air, water and soil. This destroys ecosystems and also affects the health of millions of people.

Air pollution is one of the most dangerous types. The main reasons are car exhausts, factory emissions and burning of coal and oil. Harmful gases like carbon monoxide, sulfur dioxide and nitrogen oxides, as well as small dust particles get into our lungs and blood. Many people have breathing problems, asthma, heart diseases and even cancer because of the dirty air. According to the World Health Organization about nine million people die from diseases caused by air pollution every year.

Water pollution is another big problem. Waste from factories and farms, pesticides, heavy metals and plastic poison rivers, lakes and oceans. In some countries, people don't have clean drinking water. Polluted water can cause stomach infections, problems with the liver or kidneys and other health issues. Scientists have also found microplastics in fish and even in bottled water, which is slowly collected in the body and can be dangerous in the long term.

Soil pollution is harmful too. When fertilizers, oil and chemicals get into the ground, they reach the plants and food we eat. It can cause poisoning, problems with the immune system and different diseases. Pollution also destroys the natural balance, reduces the number of animals and plants and makes climate change faster, which also affects peoples' health and life.

To stop pollution, we all need to act: schools should teach young people to take care of nature and live in a way that protects the planet.

But each person can help too. Even small actions: using less plastic, saving water and electricity,

sorting garbage, or joining eco-projects really matter. Protecting nature means protecting ourselves and the future of our planet. The fight against pollution is not only a scientific problem but also our moral duty as humans.

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ENVIRONMENTAL SAFETY

Environmental safety is a condition of the environment that ensures the protection of human life and health, the stable functioning of natural ecosystems, and the prevention of natural resource degradation. In modern conditions, the issue of environmental safety is becoming especially important due to intensive technological development, climate change, and pollution of air, water, and soil.

The main threats to environmental safety include industrial emissions, irrational use of natural resources, uncontrolled growth of waste, deforestation, military actions, and accidents at facilities of technological risk. In Ukraine, urgent problems include air pollution in cities, soil degradation, lack of clean drinking water, and consequences of technological disasters such as the Chornobyl catastrophe.

Ensuring environmental safety requires state regulation, compliance with environmental legislation, implementation of clean technologies, and ecological awareness. Monitoring systems play an important role, allowing the timely detection of dangerous changes.

International cooperation and environmental standards are also essential. Transition to sustainable development, renewable energy use, reduction of greenhouse gas emissions, and improved waste management are key to protecting the environment.

Therefore, environmental safety is a crucial component of national and global security and requires joint efforts from government, business, and society.

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THE ROLE OF PACKAGING IN FOOD INDUSTRY

In food technology, packaging's role is multifaceted, primarily focusing on protection and preservation of food by preventing contamination and spoilage, thereby extending shelf life and maintaining nutritional quality. It also serves communicative functions by providing essential information like ingredients, nutrition facts, and expiry dates. Furthermore, packaging enables convenience for consumers and facilitates transportation and logistics.

When we go to a supermarket, we see thousands of products. Each product is in some kind of packaging: plastic, glass, paper, metal, or even biodegradable materials. At first, packaging may look simple. It seems that it only holds the product. But in fact, packaging plays many important roles in food technology and in our daily life.

The main role of packaging is protection. Food is sensitive: it can get spoiled by air, water, bacteria, or light. For example, milk in a transparent bottle would turn bad very quickly, because sunlight destroys vitamins and changes its taste. That is why milk is usually sold in cartons or opaque plastic bottles. Glass jars protect jam from bacteria and keep it sweet for months.

Another reason why packaging matters is transportation. Imagine carrying flour without a bag, or juice without a box. Packaging makes food easy to move, store, and sell. Strong cardboard boxes allow factories to send hundreds of chocolate bars across countries. Plastic bottles are light, so water is cheaper to transport. Without packaging, global trade in food would be almost impossible.

Packaging also speaks to us. On every label, we can find important information: ingredients, nutrition facts, expiration dates, and storage instructions. For example, a can of beans may say “High in protein” or “Best before March 2026.” This information helps consumers make healthy and safe choices. In many countries, food companies are legally required to print this information.

Food companies use packaging to attract customers. Bright colors, nice pictures, and creative designs make products more attractive. Think of potato chips: the packaging is colorful, often with pictures of happy people or fresh potatoes. This design makes us want to buy it. Even the shape of a bottle or a box can make a product more popular. For example, the unique shape of a Coca-Cola bottle has become a symbol recognized all over the world.

In modern times, we face a big problem: too much plastic waste. Traditional packaging protects food but often harms the environment. That is why food technology is moving toward eco-friendly solutions. Companies now use biodegradable plastics, recycled paper, or even edible packaging. For example, some coffee shops offer cups made from rice husks, which can decompose naturally. In the future, sustainable packaging will be one of the most important directions in food science.

Bread is usually packed in plastic to keep it soft, but artisan bread may be wrapped in paper to ‘‘breathe’’ and stay crispy. Frozen vegetables are sealed in plastic bags to prevent ice from damaging the product. Wine is sold in glass bottles because glass does not change its taste. Yogurt comes in small plastic or cardboard cups with foil lids, which protect it from bacteria.

Packaging is not only a cover. It is a science that connects protection, transportation, information, marketing, and sustainability. Without packaging, we could not enjoy fresh milk, safe meat, or sweet chocolate. It is one of the most important parts of modern food technology.

To sum up, packaging reduces total waste by extending the shelf-life of foods, thereby prolonging their usability. Package design and construction play a significant role in determining the shelf life of a food product.

SECTION 7.
MODERN TECHNOLOGIES IN BUILDING

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APPLICATION OF FOAMED BITUMEN IN COLD RECYCLING TECHNOLOGY FOR ROAD PAVEMENT REPAIR

Modern road construction is increasingly oriented toward the principles of sustainable development, which involve reducing the use of natural resources, reusing materials, and minimizing the carbon footprint [3;2]. One of the most effective technological approaches that meets these requirements is cold recycling technology using foamed bitumen or bituminous emulsions [1;2;3;4]. Cold recycling enables the reuse of reclaimed asphalt pavement (RAP), reclaimed cement concrete (RC), and recycled aggregate (RA), significantly reducing the need for new materials and energy consumption during road construction and reconstruction [1;3;4].

The addition of foamed asphalt and foamed bitumen substantially lowers the mixing and laying temperature of asphalt mixtures, reducing CO_2 emissions and energy use while maintaining mechanical properties comparable to hot-mix asphalt [3;4]. Foamed bitumen (or foamed asphalt) is produced by mechanically activating hot bitumen (160–180 °C) with the injection of 1–2% water under compressed air pressure, resulting in a 10–20-fold volume increase and a temporary reduction in viscosity [2;3]. This process ensures high mixability with cold and moist aggregates, including up to 100% reclaimed asphalt and reclaimed cement concrete [1;3;4].

It should be noted that the type and amount of recycled material significantly affect strength parameters [2;3]. Increasing RAP content to 50–70% enhances mixture stiffness, while exceeding this level may reduce cohesion; adding reclaimed cement concrete (RC) improves the modulus of elasticity but increases moisture sensitivity [2;3]. Studies show that Portland cement substantially increases density and compressive strength [2;4]. For instance, a mixture with 95% RAP, 2.9% cement, and 2% water exhibited the highest average density and maximum compressive strength [4]. The inclusion of bituminous emulsion improves plasticity and moisture resistance but slightly reduces density [3;4]. Research highlights that adding cement and bituminous components significantly lowers water absorption, enhances durability, and provides excellent frost resistance, making these mixtures suitable even in cold climates [2; 3]. The dynamic modulus of elasticity (E) for foamed bitumen mixtures ranged from 171 to 4075 MPa, depending on temperature and composition; even at lower densities, bituminous emulsion ensures more uniform deformation behavior and reduced susceptibility to cracking under cyclic loading [3].

Choosing foamed bitumen technology is essentially a shift toward an actively controlled engineering process, as opposed to the passive, weather-dependent stabilization method using emulsions [3;4]. It provides predictability, quality, and durability of the road structure [2;3]. Although this technology requires higher personnel qualifications and strict adherence to process parameters, it eliminates key operational risks (weather dependency, prolonged curing) inherent in emulsion-based methods and creates a structural layer with superior performance characteristics [3;4]. Thus, the risks of foamed bitumen technology shift from operational to technological [2; 3].

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METHODS AND MEASURES TO INCREASE THE SURVIVAL OF FORTIFICATION STRUCTURES

The survivability of fortifications is a key aspect of ensuring the effectiveness of defensive actions. Changes in the way warfare is conducted, the emergence of new weapons, and the improvement of war tactics necessitate the continuous development and improvement of methods for protecting military facilities.

Improving the survivability of fortifications involves a set of measures covering design, technological, organisational, planning and operational aspects. This requires effective planning, the application of modern engineering solutions, the improvement of fortification construction tactics and the proper training of personnel.

Structural measures to increase survivability are aimed at improving fortifications, increasing their resistance to various types of strikes and reducing their vulnerability to modern means of destruction [1]. The main principles of structural protection include
- the use of multi-layer protective structures;
- the use of durable materials with improved blast wave absorption characteristics;
- the design of structural elements with a view to minimising damage zones;
- the introduction of modular structures for rapid conversion of structures in accordance with tactical requirements.

Technological measures to increase survivability include improving fortification construction processes and using specialised technical means. Important steps are
- using specialised construction teams to speed up the construction of fortifications;
- rational use of JCB-3CX excavators for earthworks and material transportation;
- introduction of additional protective elements (metal grilles, camouflage structures) to protect against FPV drones;
- optimization of logistics for the delivery of materials to the construction site.

Organisational measures to increase survivability are aimed at the correct placement of fortifications, their adaptation to the real combat situation and taking into account personnel limitations. Key aspects are
- conducting reconnaissance of the area before the start of construction work;
- reducing the size of platoon strongpoints to account for insufficient troop numbers;
- locating fortifications taking into account natural camouflage factors (forest belts, terrain folds);
- using mock-ups of equipment to mislead the enemy.

Planning methods for increasing survivability involve the advantageous placement of defensive positions and the correct design of fortification construction schemes. Important aspects are
- optimal placement of firepower on elevated terrain;
- camouflaging fortifications by integrating them into the natural landscape;
- determining the service life of trenches to avoid their destruction;
- systematic delivery of materials, taking into account the characteristics of the road infrastructure.

Operational measures to increase survivability focus on improving the design of military shelters and implementing infrastructure solutions to improve the functioning of units [2]. These include
- use of quick-assembly fortifications (KVS-U, UGS);

- introduction of auxiliary structures (ammunition depots, woodsheds, canteens, bathhouses);
- provision of a drainage system to reduce the risk of flooding of defensive structures;
- use of additional camouflage means to protect against enemy reconnaissance.

Improving the survivability of fortifications is a multifaceted process that requires a comprehensive approach and interaction between various fields of military engineering. Rational planning, technological innovations, organisational and operational measures contribute to increasing the level of defence capability and protection of military units.

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CHANGES IN FORTIFICATION CONSTRUCTION PRACTICES AMID FULL-SCALE INVASION

Since the onset of the full-scale invasion of Ukraine, approaches to the construction of military structures have undergone significant changes. In modern warfare conditions, particular attention is paid to strengthening defensive positions and enhancing their survivability and effectiveness. Existing documentation for the construction of fortification structures [1] requires updates, especially regarding vertical protection of defensive positions.

A critical element of fortification protection is the installation of continuous overhead cover for trenches and enclosed firing positions. This contributes to reducing personnel losses and improving the combat effectiveness of units. Such cover performs several key functions:

Physical protection: Reduces the risk of personnel injury from shrapnel and blast waves.

Climatic insulation: Provides more comfortable conditions in trenches during adverse weather.

Camouflage: Decreases visibility of positions from aerial and ground reconnaissance.

The continuous cover consists of three main components [2, pp. 4–6]:

Frame – The base of the cover may be constructed from wooden elements or arched metal profiles.

Waterproofing layer – Prevents moisture penetration into trenches; materials may include polyethylene film or bituminous compounds.

Protective soil layer – A compacted layer 50–60 cm thick provides additional blast protection and camouflage.

The frame can be built using logs with a diameter of 20–25 cm or arched metal profiles with a width of at least 1900 mm and a thickness of 2 mm or more. When constructing a wooden frame, logs of various diameters should be used to ensure a strong supporting structure.

To provide natural lighting in covered trenches, windows should be installed at a density of one window per trench facade section. These windows are covered with metal mesh to prevent foreign object intrusion. Additional camouflage is achieved using local vegetation or specialized camouflage nets [2, p. 7].

Materials Required for 10 Linear Meters of Wooden-Covered Trench:

Logs with a diameter of 20–25 cm – 1 m^3

Logs with a diameter of 10–15 cm – 2.8 m^3

Polyethylene film – 30 m^2

Construction staples – 140 pcs

The installation of continuous overhead cover for trenches and enclosed firing positions significantly enhances personnel protection, supports combat readiness, and ensures more comfortable conditions at defensive positions. Additional design solutions such as waterproofing, camouflage, and lighting openings improve the functionality of the shelter and make it more effective in tactical applications.

Given the current challenges in defense construction, it is advisable to implement effective shelter construction methodologies in military practice. This will improve personnel survivability and increase the overall defensive capability of units.

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USE OF SOFTWARE AND ARTIFICIAL INTELLIGENCE FOR SURVIVABILITY ANALYSIS OF BRIDGE STRUCTURES AND FORTIFICATIONS

Modern warfare requires military engineers to build quickly, economically, and with high quality. Simultaneously, with the development of high-precision weapons and the massive use of unmanned systems, the risks to critical infrastructure, particularly bridge crossings, and personnel increase significantly. This creates an urgent need for the design and analysis of non-typical and reliable structures: anti-drone screens, mobile metal and concrete shelters, as well as in-depth survivability analysis of existing bridge structures and fortifications.

Calculation methods based on static or linear dynamic loads are unable to describe the complex nonlinear processes that occur during an explosion: perforation, cratering, spalling, and complete failure.

The development, in-depth study, and application of modern software complexes (SC) combined with artificial intelligence (AI) methods can help address these tasks.

Software Complexes for Survivability Analysis

A number of software complexes operating on the finite element method (FEM) are used for calculations. They can be conditionally divided by their specialization:

SC for General Construction Calculations (SCAD, Lira-SAPR):

SCAD – a software complex for the strength analysis of structures. It provides the ability to perform static and dynamic calculations (seismic, impulse), stability analysis, design load combinations, and bearing capacity checks.

Lira-SAPR – a platform based on BIM (Building Information Modelling) technology, used for designing a wide range of objects, from bridges and bunkers to high-rise buildings.

These complexes are indispensable for designing structures under operational and design loads. However, for survivability analysis, which involves short-term, high-energy events, their functionality is insufficient.

SC for Explicit Dynamic Analysis (Ansys LS-DYNA):

Ansys LS-DYNA is a software complex for modeling nonlinear, short-term dynamic processes. Unlike implicit calculations (used in SCAD and Lira for analyzing statics or low-frequency dynamics), the explicit method allows modeling the response of materials to strong impact loads. This tool is used for analyzing explosions, ballistic perforation, high-velocity impacts on concrete and metal shelters, and the behavior of composite armor. This makes it an ideal tool for calculating anti-drone structures, protective shelters, and analyzing the survivability of bridges and shelters.

Mathematical Models for Simulating Failure. Modeling Concrete and Geomaterials To describe the behavior of brittle materials (concrete, soil, ceramics) under impact, complex models are used that account for the dependence of strength on pressure and strain rate.

- JOHNSON-HOLMQUIST: The most common model for simulating concrete under ballistic impacts. It accounts for damage accumulation and the dependence of strength on pressure. The model has been successfully used for the dynamic analysis of reinforced concrete columns under blast loading and for analyzing the perforation of high-strength fiber-reinforced concrete slabs.
- RIEDEL-HIERMAIER-THOMA: A modern model developed to describe the dynamic strength of concrete. It details the material's behavior after the onset of failure and is used for analyzing contact explosions on reinforced concrete beams.

Modeling Steel (Rebar, Metal Shelters) For metals, the key is to describe plasticity and failure at high strain rates.

- JOHNSON-COOK: The industry standard for modeling metals. Its advantage lies in accounting for three key effects: strain hardening, strain rate sensitivity, and thermal softening due to heating in the impact zone. This model has been validated multiple times, demonstrating high correspondence between simulations of armor plate perforation (e.g., by 12.7-mm and 9-mm bullets) and real experimental data.

Modeling Explosive Loading There are two main approaches to simulating an explosion:

LOAD BLAST ENHANCED (LBE): A simplified method that calculates the pressure on the structure's surface. This is a fast method, ideal for the initial survivability assessment of long-span bridges and shelters.

ALE (Arbitrary Lagrangian-Eulerian): The most accurate, but resource-intensive method. It models the explosive, air, and their interaction as fluid, and the structure itself as a solid. This method allows modeling complex blast wave focusing effects.

Artificial Intelligence for Survivability Optimization. The main problem with detailed FEM analysis in LS-DYNA is its extreme resource intensity—a single calculation can take a long time. This makes traditional structural optimization, which requires thousands of iterations, impossible.

This is where the synergy of FEM and artificial intelligence (AI) provides revolutionary opportunities. The optimization process is divided into two stages:

Stage 1. Creating a "Surrogate Model" A surrogate model is, in essence, a "digital twin" or an approximation of a complex FEM model, created using machine learning (ML).

- Sampling: The engineer conducts a limited number (100-200) of full FEM simulations with different input parameters (e.g., different slab thicknesses, rebar spacing).
- Training: An AI model (e.g., a Deep Neural Network (DNN) or a Graph Neural Network (GNN)) "learns" from this data, finding hidden relationships between the geometry and the result (damage level).
- Result: The AI model is capable of predicting the result of a complex simulation in fractions of a second. Studies show that surrogate models can speed up calculations by hundreds of times while maintaining accuracy at 97-99% compared to a full FEM calculation.

Stage 2. Optimization using Genetic Algorithms (GA) Having an ultra-fast surrogate model, the engineer can launch an automated optimization process.

- Problem Statement: The goal might be, for example, to minimize the weight of a shelter while ensuring it withstands a direct hit from a specific munition.
- "Evolution" of the Structure: The genetic algorithm creates a "population" of thousands of design variants. It instantly checks the "survivability" of each variant using the surrogate model. The best designs (lightweight and strong) are combined to create a new, even better design.
- Result: In a matter of minutes, the algorithm iterates through millions of options and finds the optimal design.

The survivability analysis of bridge structures and fortifications in modern conditions is a complex task that requires a combination of advanced tools.

Using software complexes with nonlinear explicit analysis (like Ansys LS-DYNA) is necessary to obtain a reliable picture of failure from explosions and impacts.

The key to accuracy is the application of validated mathematical material models, such as Johnson-Cook for steel and Johnson-Holmquist (JH-2) or RHT for concrete, which correctly describe their behavior under extreme loads.

Direct optimization of such structures is impossible due to the extremely high time costs of FEM calculations.

The synergy of FEM and artificial intelligence—through the creation of surrogate models and their subsequent optimization using genetic algorithms—solves this problem, enabling the design of lightweight, economical, and highly effective protective structures in short timeframes, which is critically important in combat conditions.

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RECYCLING MATERIALS IN BUILDING ENGINEERING: ADVANCING SUSTAINABILITY AND INNOVATION IN CONSTRUCTION

Recycling materials in building engineering is an effective approach to reducing waste, conserving resources, and promoting sustainability in construction. As the construction industry is one of the largest consumers of raw materials and generates substantial waste, incorporating recycled materials is an increasingly popular and impactful strategy. Recycled materials are not only eco-friendly but also cost-effective, helping reduce the demand for new resources while supporting the development of durable and efficient building structures.

One common recycled material used in building engineering is recycled concrete. Concrete is one of the most widely used building materials globally, yet it contributes significantly to construction waste when demolished. Through a process called “crushing,” demolished concrete can be broken down and repurposed as aggregate, which can then be used as a base material for new construction projects. Recycled concrete aggregate (RCA) can effectively replace natural gravel in road construction, foundations, and even as part of new concrete mixes, reducing the need for mining new aggregate materials. Using RCA helps lower disposal costs and minimizes the environmental impact of extracting new materials.

Recycled steel is another vital material in sustainable building engineering. Steel is inherently recyclable, meaning it can be melted down and reformed repeatedly without losing its strength or quality. Using recycled steel conserves energy, as it requires significantly less energy to recycle steel than to produce new steel from raw ore. Additionally, recycled steel has applications in both structural and architectural elements of construction, from framing and beams to reinforcing bars in concrete structures. By choosing recycled steel, engineers and builders help lower greenhouse gas emissions associated with steel production and reduce mining for raw materials.

Glass is another widely recycled material, particularly in window manufacturing and interior finishes. Recycled glass can be used to create various construction materials, including countertops, wall tiles, and insulation products like glass wool. Recycled glass is not only environmentally friendly but also adds aesthetic value to buildings through its unique textures and colours. In addition, using recycled glass reduces landfill waste and cuts down on the need for virgin materials like sand, which is increasingly scarce due to over-extraction.

Plastic recycling is becoming more prevalent in building engineering as well, especially as innovations allow for recycled plastic to be incorporated into construction materials. Recycled plastic can be found in items such as roofing tiles, wall panels, and insulation products. Some companies have even developed plastic composite materials that serve as alternatives to traditional wood and metal. These materials are lightweight, durable, and resistant to moisture, making them ideal for use in various building applications. Additionally, incorporating recycled plastics into construction helps address the environmental challenge of plastic waste, which is a persistent issue worldwide.

Recycling materials in building engineering offers numerous benefits, from lowering construction costs and conserving resources to reducing environmental impact. By integrating recycled materials like concrete, steel, glass, plastic, and wood into building projects, the construction industry can move toward a more sustainable, responsible approach to development.

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TRANSFORMATION OF SUPPORT POINTS OF SUBDIVISIONS UNDER THE INFLUENCE OF CURRENT CHALLENGES AND THREATS

Improving the survivability of fortifications is a complex undertaking that requires careful planning, new approaches, the use of modern technologies, and appropriate training of personnel. The experience of war has made adjustments to the approaches to the effective construction of fortifications.

To increase the pace of construction work on the site of fortification structures as part of a platoon strongpoint (hereinafter referred to as PS), it is advisable to use trained specialized teams that perform the same type of construction work. Based on experience, it is possible to form optimal teams with the involvement of equipment to perform work on the construction of PS.

Achieving a sufficient level of survivability of fortifications is only possible with strict adherence to diagrams, designs, and instructions for their use. Unfinished or poorly constructed structures can do more harm than good.

Camouflage kits were the main means of concealing positions and fortifications. The actual need for them to effectively camouflage positions exceeds their available quantity many times over. A partial solution to the problem is the use of field and industrially manufactured nets with vegetation elements woven into them.

The combat regulations of the Armed Forces of Ukraine, part 3, establish the dimensions of a mechanized unit's platoon strongpoint: up to 400 m along the front and up to 300 m in depth. These dimensions were justified by the standard strength and ability to conduct effective defensive combat. Currently, the actual shortage in units may be 60–70%. The personnel in such units are not capable of effectively performing combat tasks at a standard platoon strongpoint. Therefore, it is advisable to reduce the unit's strongpoint: 100-150 m along the front and up to 50 m in depth, with trenches covered and closed firing positions set up. Adjacent strongpoints should be covered by fire from neighboring ones to ensure coverage of the entire front.

However, maximum communication and coordination must be established.

The best option for setting up strongpoint positions is to place firepower positions on the front slopes of the heights. In the eastern and southeastern parts of Ukraine, flat steppe terrain without significant elevation changes prevails, so strongpoint positions should be placed under the cover of forest belts, and communication routes should be built into the folds of the terrain.

To create comfortable and safe conditions for the daily activities of the units occupying the strongpoint, it is advisable to construct auxiliary facilities. Such facilities include: an ammunition depot, a fuel and lubricants depot, and a latrine. In the future, it is advisable to construct a kitchen, a dining room, a bathhouse, and a woodshed.

Therefore, summarizing the results of this study, we conclude that in modern realities, the transformation of unit strongholds is aimed at increasing their adaptability, security, and ability to conduct effective defense in modern combat conditions.

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MODERN TECHNOLOGIES IN CONSTRUCTION: CURRENT ACHIEVEMENTS

The construction industry is undergoing a rapid, technology-driven transformation, shifting from traditional, labour-intensive methods to highly efficient, digital, and sustainable practices. This revolution is fundamentally changing how we design, build, and manage infrastructure.

Digital Transformation: The Foundations

The most significant change is the widespread adoption of digital tools that enhance planning, collaboration, and execution:

Building Information Modeling (BIM): BIM has become the cornerstone of modern construction. It allows architects, engineers, and contractors to create detailed 3D models of a building, which serve as a single, centralized source of information throughout the entire project lifecycle. This helps in early conflict detection, accurate quantity takeoffs, and streamlined project management.

Digital Twins: These are virtual replicas of physical assets (a building or infrastructure system) that are continuously updated with real-time data from sensors. Digital Twins are used for monitoring performance, predicting maintenance needs, and optimizing the building's operation long after construction is complete.

Virtual and Augmented Reality (VR/AR): VR and AR tools allow stakeholders to visually tour the building design before construction begins. AR overlays digital models onto the real job site, aiding workers with complex assembly or inspection tasks, reducing errors, and improving safety training.

Innovative Construction Methods (Off-Site and Automated)

Modern methods of construction (MMC) prioritize efficiency, speed, and quality control, often by moving manufacturing away from the volatile construction site.

Modular and Prefabricated Construction: This involves manufacturing large components (panels, beams, or entire 3D room modules) in a controlled factory setting. These components are then transported and rapidly assembled on-site. Benefits include reduced waste, improved quality control, and significant cuts in project timelines.

3D Printing (Additive Manufacturing): 3D Concrete Printing is a game-changer, enabling the creation of intricate or bespoke structural elements, and in some cases, entire homes, in days rather than months. This method uses less material and automates labour.

Robotics and Automation: Construction robots, such as automated bricklaying machines and autonomous vehicles for material transport, increase precision, accelerate tasks, and improve safety by handling hazardous or repetitive work.

Modern construction places a high emphasis on sustainability and energy performance.

Sustainable Materials: There is a growing focus on using materials with a low-carbon footprint, such as Cross-Laminated Timber (CLT), recycled concrete, and self-healing concrete (which uses embedded bacteria to autonomously seal cracks).

Green Roofs and Smart Systems: Engineers integrate smart sensors and building management systems to actively monitor and optimize a building's energy consumption, lighting, and HVAC systems. Green roofs and living walls are incorporated to improve insulation, manage stormwater, and reduce the urban heat island effect.

In conclusion, modern construction technologies are not just about faster building; they are about creating a more efficient, safer, and ecologically responsible built environment. The future of the industry lies in the seamless integration of digital planning, off-site manufacturing, and smart, sustainable materials.

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SOME MODERN TECHNOLOGIES IN CURRENT CONSTRUCTION FIELD

Building houses is a complex and responsible process. The main requirements for modern houses are reliability, durability, thermal insulation, and sound insulation. To achieve these qualities, modern technologies are increasingly being used in house construction.

Over the past 10-20 years, many new technologies and processes have appeared in construction. Let's look at some innovative changes:

1. BIM (Building Information Modeling). This is information modeling that allows you to evaluate the profitability of a project. Thanks to the program, the developer can quickly prepare the necessary documents and calculate the profit he will receive from construction.
2. The use of 3D printers for construction. Only leading construction companies use printers to manufacture certain elements of a house. But there are already several houses in the world that have been built exclusively with the help of a 3D printer. The complexity of applying this technology lies in its high cost.
3. Use of drones. Drones can be used to take photographs from above, assess the scale of construction, and identify problem areas. Drones also help to assess the nearby infrastructure and take some beautiful promotional photos for investors. These devices are also used for security purposes. When it comes to large facilities, it is quite difficult for security guards to patrol them, so round-the-clock drone patrols are an excellent solution.
4. Smart Home/Building Systems. Smart Home systems allow you to automate control over building life support, optimizing resource consumption. They include centralized control of heating, ventilation, and security.
5. Modular Construction. The essence of this technology is that the main parts or entire rooms of a house (modules) are assembled in a factory under controlled conditions. After manufacture, the finished modules are transported to the construction site, where they are quickly assembled on site, which can reduce construction time by 30-50% compared to traditional methods, which in turn reduces overall costs.

New technologies are aimed at making housing more comfortable and affordable, as well as reducing construction times. Many technologies are aimed at reducing construction time and, as a result, reducing costs.

1. Penetrating waterproofing. The essence of this technology is to impregnate concrete with a special solution that penetrates the pores and crystallizes. This blocks moisture penetration and significantly increases the service life of the building.
2. Permanent formwork. This technology is currently very popular in house construction. Its advantages are low housing costs and high construction speed. This technology provides monolithic walls, but the formwork itself does not need to be removed.
3. Smog absorption. Such houses absorb all harmful impurities that settle on the surface of the building. This technology is currently actively used in Japan, but it is relevant for any large city, including Kyiv.
4. Tensioned reinforcement. This is a method of hardening steel, which makes the reinforcement extremely strong and capable of withstanding enormous loads. This technology is increasingly used in the construction of buildings with heavy loads on the walls and ceiling.

The use of the latest technologies in construction not only helps to reduce costs and speed up completion times, but also ensures that buildings meet modern requirements for sustainable development and energy efficiency.

SECTION 8. HUMANITIES AS THE COMPONENT OF THE PROFESSIONAL TRAINING

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INNOVATIVE LEXIS IN THE IT SPHERE: EMERGING VOCABULARY AND ITS IMPACT

In the rapidly evolving domain of information technology (IT), language keeps pace with innovation: new words, meanings, and usages emerge constantly to capture novel concepts, tools, and processes. This phenomenon highlights how language adapts to accommodate technological change. For instance, terms such as *blockchain*, *fintech*, *deep-fake*, and *quantum cloud* enter the common IT lexicon to label recently invented technologies or hybrid practices. The purpose of this text is to explore how innovative lexis develops in the IT sphere, the mechanisms that drive its diffusion, and implications for learners and professionals in English for Specific Purposes (ESP) contexts.

Firstly, innovation in IT lexis often stems from the need to name emerging technologies and workflows that previously lacked vocabulary. As new systems – such as generative AI, edge computing, or metaverse strategies – arrive, industry professionals coin terminology to describe them succinctly and effectively. These neologisms frequently employ blending (e.g., *webinar*), compounding (e.g., *cloud migration*), or semantic extension (e.g., *virus → computer virus*). Recent studies show that lexical innovation thrives in technical fields where naming is essential for communication and coordination. Once conceptualised and used within communities, these terms diffuse via specialist publications, online forums, conferences and social networks, gradually becoming standard vocabulary in IT discourse.

Secondly, the diffusion and institutionalisation of new IT lexis depend on social and textual networks. There is a pattern: a new term begins with limited use, becomes widely adopted as its concept gains traction, and eventually stabilises as part of the general lexicon. This dynamic is especially visible in the IT world: for example, *cybersecurity* moved from niche use to mainstream prominence as concerns about digital threats grew. Moreover, lexical innovation within IT highlights that vocabulary change is shaped by both technological innovation and social adoption.

Thirdly, from an educational and professional perspective, understanding innovative IT lexis is vital. Learners of English for Specific Purposes must acquire not only general vocabulary but also emergent domain-specific terminology to remain current in their field. For instance, mastering micro-terms like *devops pipeline*, *docker container*, or *zero-trust architecture* enhances one's capacity to communicate with peers, follow literature, and participate effectively in a global IT community. However, there are challenges linked to lexis innovation in IT. Rapid terminology change means that learners and even professionals may face difficulty distinguishing between transient buzzwords and established, useful terms.

In conclusion, the IT sphere represents a rich setting for lexical innovation: new words emerge swiftly, spread rapidly through digital and professional networks, and become integral to technological discourse. For English learners and professionals, keeping up with this vocabulary is not merely a matter of memorising definitions but engaging with the mechanisms of change, understanding formation patterns, and participating in ongoing professional communication. Integrating strategies for recognising and adapting to new lexis supports both linguistic competence and professional effectiveness in the world of IT.

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THE ART OF BALANCING. FEATURES OF TRANSLATING ENGLISH-LANGUAGE SONGS INTO UKRAINIAN, USING THE SONG «UNDER THE SEA» FROM THE ANIMATED FILM «THE LITTLE MERMAID» AS AN EXAMPLE

Song translation is a special genre of creativity, where words are subject not only to meaning, but also to music, rhythm, rhyme and cultural context. A striking example of this is the Ukrainian translation of the legendary song «Under the Sea» from the cartoon The Little Mermaid. Comparing the original and the translation «На глибині» (In the depths), we see how the translator does not simply translate the words, but creates a new artistic reality, preserving the spirit of the original while giving it a Ukrainian sound. Music carries universal messages. However, music translation services can be challenging, especially due to cultural differences. Songs are a product of culture, and maintaining the meaning and message of lyrics in a new cultural context can be challenging.

Linguistic features and their impact on translation were considered, as one of the main reasons for differences between the original and the translation lies in the differences between English and Ukrainian. English allows for concise expression thanks to short words and syntactic flexibility. For example, the title «Under the Sea» is a short, rhythmic and at the same time figurative phrase. In Ukrainian, however, a direct translation is simply infeasible. That is why the translator chose «На глибині» (In the depths) to convey this idea in Ukrainian. Although this option sounds natural, it slightly shifts the emphasis from the image of the underwater world to a specific physical location. Likewise, longer phrases such as «Darling it's better, down where it's wetter» require adaptation due to rhythm and euphony. The translation «Крабу видніше, що вигідніше» (The crab sees better, it's more profitable) creates a new shade of meaning, adding a touch of rationality and straightforward humour characteristic of Ukrainian culture.

Another important task for a translator is to create an emotional connection through cultural adaptations. In the Ukrainian translation, however, the emphasis has shifted: more attention is paid to the drama and contrast between hard work on land and freedom underwater. For example, the phrase «Up on the shore they work all day» is translated as «Люди на сонці, як раби» (People in the sun, like slaves). This replacement makes the message stronger and more dramatic, as the word «раби» (slaves) evokes a vivid emotional response in listeners. It is not a literal translation, but it reinforces the idea of contrast on which the entire song is based. The fragment «The seaweed is always greener in somebody else's lake» was rendered as «Чи правда, що більше зілля в сусідовому ставку?», which transforms a statement into a rhetorical question. This shift makes the line more engaging and fits better with the melody. The next line, «You dream about going up there, but that is a big mistake,» became «Чи краще живеться зверху, ніж нам тут у холодку?», maintaining the sense of curiosity and contrast between life «up there» and «down here». Again, the interrogative form creates a conversational and emotional flow that suits the song's tone.

The lines «Just look at the world around you, right here on the ocean floor. Such wonderful things surround you. What more is you lookin' for?» were rendered as «Ти тільки поглянь навколо на це океанське дно. Не знайдеш ніде ніколи гарнішого, ніж воно». Here the translator transformed the question «What more is you lookin' for?» into a statement, emphasizing the completeness and beauty of the underwater world. This shift from inquiry to affirmation strengthens the message that one should appreciate what they already have. It is not easy to translate songs, especially songs from children's cartoons, so they are as beautiful as the original and retain their meaning. Each change is a conscious choice aimed at making the text accessible and understandable to the local audience without losing the spirit of the original.

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FEATURES OF TRANSLATING EUROVISION SONGS: TRADITIONAL AND MODERN APPROACHES (HUMAN AND MACHINE TRANSLATION)

This study focuses on the translation of song lyrics in the context of the rapid development of artificial intelligence technologies. Modern AI systems, particularly neural network-based models, are increasingly used for translating literary works, including songs. They can convey meaning and partially reproduce stylistic, emotional, and rhythmic features of the original. However, the quality and artistic accuracy of such translations require careful comparison with human translations. It is in the field of song translation – where rhyme, rhythm, and cultural nuances must be harmoniously combined – that both the potential and limitations of artificial intelligence become most evident.

A song is a special object of translation because it combines verbal text with music and a performative component. According to a lexicographic definition, a song is «a short metrical composition intended or adapted for singing, especially one in rhymed stanzas; a lyric; a ballad». For a long time, song translation remained on the periphery of translation studies. Only recently have scholars begun to examine the interaction between music and translation. Ş. Susam-Saraeva notes that until recently, the field of "translation and music" was largely neglected, despite the vital role of music in everyday life and culture.

Translating vocal works, such as songs or arias, involves specific challenges. Unlike prose, song translation must preserve poetic form, rhythm, and musical compatibility. The main difficulties include maintaining rhythmical and stanzaic structure, reproducing rhyme and sound patterns, conveying cultural and linguistic realities, and reflecting the expressive-emotional coloring of the original. Research by V. Yu. Akkurt, O. Prokopenko, and R. Pastir shows that the major obstacles in translating English-language songs into Ukrainian are reproducing the original text's form and conveying cultural nuances. Strategies include transcription, calque, descriptive translation, or functional equivalents, depending on the song's genre.

Two main approaches are distinguished: literal translation and free adaptation. Literal translation preserves meaning but may sacrifice rhyme or rhythm, while free adaptation rephrases the text for performance, maintaining musicality. As J. Franzon notes, the translator must first decide whether the translation is for singing or comprehension. Effective translation balances semantic fidelity, rhythmic accuracy, and cultural adaptation to retain the song's expressive and artistic value.

The development of artificial intelligence (AI) and machine translation (MT) has opened new possibilities in song translation. Neural models can generate draft translations considering line length, rhyme, and melody. Controlled song translation integrates explicit rules into AI prompts, improving rhyme and meter consistency. Yet AI cannot fully capture stylistic individuality, imagery, or cultural context. Poetic texts rely on metaphors and sound patterns that automatic systems often misinterpret, requiring creative human intervention.

The most effective practice is a hybrid approach combining AI drafts with human refinement. AI ensures structural and rhythmic accuracy, while human translators adjust rhyme, meter, and emotional tone. Thus, AI accelerates the process and improves technical precision, but human creativity remains indispensable for preserving the artistic, emotional, and cultural integrity of the original work.

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MULTILEVEL LINGUISTIC MEANS OF EXPRESSING MODALITY IN THE TRANSLATION OF TEXTS OF VARIOUS GENRES FROM ENGLISH INTO UKRAINIAN

Modality is a universal linguistic category that reflects the speaker's attitude toward reality, the content of the statement, the degree of reality or irreality of events, and the assessment of the probability or necessity of an action. It has both objective and subjective dimensions, as it simultaneously reveals logical-grammatical relations and the speaker's emotional and evaluative stance. In translating texts of various genres and styles from English into Ukrainian, modality becomes one of the most complex elements to render adequately, since English possesses an extensive system of modal means that do not always have direct structural equivalents in Ukrainian. As M. Kocherhan notes: "The category of modality is one of the most complex and comprehensive in the language system, as it reflects both the logical and the emotional-evaluative dimensions of speech" [2].

Achieving translational equivalence requires the translator to have a profound understanding of the linguistic means of expressing modality at different levels: phonetic, lexical, and lexico-grammatical. The choice of translation strategies depends on the genre and stylistic features of the text, the communicative purpose, the author's pragmatic intent, and even the reader's expectations. In some genres (particularly literary or journalistic), modality is realised primarily through expressive-evaluative components. In contrast, in scientific or technical texts, logical and rational means of expressing certainty, probability, or assumption prevail. At the phonetic level, modality is conveyed through intonation, stress, and the rhythmic structure of the statement. These elements form the emotional and pragmatic tone of the statement, which often requires compensation in translation. In English, logical or emphatic stress may convey shades of doubt, conviction, or warning, while in Ukrainian, similar effects are more often achieved using modal particles and adverbs such as *аж, ж, таки, все ж, певне, напевне*. For example, the sentence *"How fastidious is the human memory!"* may be translated as *"Дивовижна таки людська пам'ять"* or *"Дивовижна все ж таки людська пам'ять,"* demonstrating the translator's subjective interpretive choice. Intonational devices of the English text often shift into lexical or lexico-grammatical equivalents in translation, which preserve the modal force but adapt it to the norms of Ukrainian syntax and stylistics. As T. Kyiak, O. Ohui, and A. Naumenko note, "the rendering of modal meanings in translation depends not only on grammatical counterparts but also on the interpretation of the author's communicative intention" [1].

On the lexical level, modality is revealed through the choice of words with evaluative or emotional tone. One of the most expressive means is the compound, which combines several semantic components and creates an additional shade of the author's attitude. For example, English compounds such as *wind-swept*, *rat-faced*, and *half-hopeful* not only describe external characteristics but also construct an emotional and evaluative perspective [4]. In translation, these units are rendered through analytical constructions: *де віють усі вітри*, *чоловічок із розпашілим обличчям,* and *погляд, у якому світилися страх і надія.* Which convey not only description but also the author's viewpoint, interpreting characters' psychological states and the text's atmosphere. The translator becomes a co-creator of the emotional and modal canvas of the text, since semantic accuracy and artistic expressiveness depend on the choice of appropriate lexical units.

Modal words play a special role in expressing modality, as they signal degrees of certainty, doubt, probability, or emotional reaction. English words, *perhaps*, *maybe*, *probably*, *certainly*, *undoubtedly*, *fortunately*, *unfortunately*, find Ukrainian equivalents such as *можливо*, *мабуть*, *ймовірно*, *без сумніву*, *на жаль*, *на щастя* [3]. Their selection depends not only on context but also on genre. In scientific and journalistic texts, they serve as means of logical argumentation or reinforcement of credibility, whereas in literary translation, they perform a stylistic function by conveying emotions of the author or characters. Modal words create a specific communicative space within the text, shaping the speaker's position, and the translator must strike a balance between grammatical accuracy and expressive naturalness.

Lexico-grammatical means of expressing modality include, first of all, modal verbs, which constitute the most systematised group of modal tools in English. They express various shades of possibility, necessity, obligation, assumption, permission, or desire. In translation into Ukrainian, such verbs often have direct equivalents (*can – могти*, *must – мусити, повинен*, *may – можна, дозволяти*, *have to – треба, належить*). However, in many cases, the precise choice depends on context, the degree of imperativeness, and the pragmatic purpose of the statement.

For instance, the modal verb *can* may express physical or intellectual ability and is translated as *могти*, *вміти*, *бути в змозі*, whereas in negative or interrogative constructions it may acquire the meanings of doubt or reproach: "Навряд таке житло буде всім по кишені." The verbs *may/might* express permission or assumption and are translated as *можна*, *дозволяється*, *може бути*, or more contextually: "It may result in failure" – "Це може призвести до невдачі." The verb *must* have a clear meaning of obligation, but in Ukrainian it is often softened (*має*, *напевне*), which helps avoid the excessive categorical tone typical of English.

Particularly challenging are the verbs *shall*, *will*, *would*, and *should*, which, apart from their modal meaning, also function as auxiliaries in tense formation. In English official and legal texts, *shall* conveys obligation and is translated using Ukrainian constructions such as *має*, *повинен*, *належить*. In literary texts, the same verb may express a promise, command, or solemn declaration, thus requiring interpretive translation. The modal verb *will* often express will, intention, readiness, or confidence in the action; therefore, its translation may vary from the simple future tense (*буде, буду*) to analytical constructions expressing volition (*збирається*, *прагне*). The verb *would* is highly flexible: it may convey conditionality, assumption, or politeness. In Ukrainian translation, it is rendered through the particles *би, б* or the conditional mood: "I would like to ask" – "Я хотів би запитати." Similarly, *should* expresses recommendation, moral obligation, or assumption, and is translated as *слід*, *потрібно*, *варто* or by the imperative form: "You shouldn't worry" – "Не хвилюйтесь."

Thus, English modal verbs function as a complex multilevel means of shaping meaning, combining semantic, grammatical, and pragmatic aspects. The translator must not only find a formal equivalent but also preserve functional equivalence, maintaining the communicative force of the utterance. In this context, translating modal structures requires interpretative flexibility, as the same verb may shift in categoricity, emotionality, or certainty depending on the context.

Modality in any genre, from literary to scientific-technical, performs an important cognitive-pragmatic function. It determines the method of presenting information, the level of reliability, and the intonation, and consequently shapes the reader's perception. In literary discourse, modal means create psychological depth and reflect characters' subjective worldviews; in journalistic texts, they form the author's stance and reinforce argumentation; in scientific texts, they ensure logical accuracy and the credibility of statements.

Therefore, the translator must not only reproduce the grammatical structure but also reconstruct the modal-evaluative potential of the text, which is an integral part of its meaning. The effectiveness of translating modal constructions depends on striking a balance between accuracy and naturalness, between formal features and communicative effect.

As a result, multilevel linguistic means of expressing modality in the translation of texts of various genres reflect the deep interaction of structural and pragmatic factors. Phonetic means shape the emotional contour of the statement; lexical means create its evaluative-emotional tone; and lexico-grammatical means ensure logical-grammatical cohesion and express degrees of reality or irreality. Modality is one of the components of the language system that most fully reveals the individuality of both the author and the translator. Its adequate rendering ensures communicative balance between the original and the translation, which is a key condition of translational mastery.

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TO THE PROBLEM OF TRANSLATION OF VISUAL NOVELS

A visual novel (further – VN) is a special type of text-based game where the player can read a story which consists of character dialogues, their thoughts, and feelings. The text is accompanied by vivid illustrations, sound, and animation. VNs are interactive games: the players make choices depending on the specific situation, which will lead to one logical ending or another. Also, players can choose appearance and sometimes name of the main character. Many VNs allow you not only choose the direction of the plot, but also love interest of the main character you can build relationship with. It gives you incredible experience of creating your own story, depending on different choices and roots.

Visual novels first appeared in Japan and during the last decade became widespread all over the world. COVID-19 pandemic skyrocketed their popularity, as people wanted to find some engaging activities while staying at home. VNs have established themselves not only thanks to the unique interactive experience where the players could fully define looks, personalities and destiny of the characters. Moreover, a lot of VN apps have more than one story inside. For example, one of the most popular games of the type called ‘Romance Club’ offers more than forty stories in different genres: fantasy, crime, historical reconstruction, etc. New episodes usually come up once a month, keeping the readers excited about the plot. The key factor in VNs’ popularity is the rising costs of paper books – it is easier for people to read more stories with the help of the gadgets.

As visual novels are getting more widespread, game designers are getting more interested in translating their stories into different languages, and thus making them available worldwide. In addition, foreign authors are often invited to write new stories. For example, a Ukrainian VN app ‘Neo Story’ has an Australian author writing a story ‘Titanic: Dance of Dante’s Inferno’ for them, which sparks the need for quality translation. There is plenty of studies exploring technical side of designing a VN app, but only a few studies focused on translation, while text remains the most essential part of the stories. Therefore, this topic is quite relevant and underexplored.

Translation from English into Ukrainian is often challenging because of the difference in grammatical structure of the languages. Accordingly, translated sentences can sound unnatural for the recipient language. In general, all rules of the translation of fiction apply to VNs as well. However, it is important to remember, that in visual novels text appears partially – the player can see only two-three sentences on screen at once. Then slides change so that the players read the next portion. That’s why translators of VNs have to be particularly attentive to the repetitions and substitution of the words. The sentences mostly have brief and logical structure. Specifically, in VNs the translators have less opportunities to explain the meaning of unusual words to the readers. So, borrowings from English should be limited. Instead, it is common to use adaptation and localization to ensure that the text would be understandable for the foreign players. It includes finding appropriate equivalents for the idioms and collocations. The translators also have to decide on what method is more convenient for adaptation of the foreign names. Research into the translation of visual novels is a promising area for the future development of this type of game and its marketing potential.

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THE EMOTIONAL STRUCTURE AND VERBALIZATION OF THE CONCEPT "VAMPIRE" IN THE COGNITIVE-LINGUISTIC DIMENSION

In modern linguistics, the study of concepts involves a combination of cognitive, cultural, and linguistic approaches, since it is through language that the interaction between thought and culture is realised. The analysis of the concept "Vampire" makes it possible to understand how cultural representations of mythical images with a clearly expressed emotional component are formed and transformed. Methodologically, such research relies on conceptual analysis, which, according to M. Kocherhan, combines general scientific and specialised methods, including componential, definitional, psycholinguistic, cognitive-discursive, and modelling techniques [1]. The latter plays a leading role in constructing the model of the studied concept, as it enables the identification of its structure, emotional field, associative chains, and value orientations that reflect the collective consciousness of speakers.

The aim of conceptual analysis is not only to establish the meaning of the representative word but also to reveal its internal semantics, etymology, metaphorical and symbolic connections [4]. In the study of the concept "Vampire," the first step is the analysis of the lexeme itself, which serves as the nominative unit for this notion. Through the semantic field of the word, we can identify cognitive features forming the core of the concept. At the same time, the periphery includes sub-concepts and associative chains that expand its emotional and semantic content [3]. This approach enables the reconstruction of an integral conceptual model, in which every lexeme or metaphor serves as an element of a unified cognitive system.

The structural organisation of the concept "Vampire" is hierarchical and field-based. At its centre is the core, the representative word *vampire*, around which synonyms and associative lexemes (Dracula, Nosferatu, bloodsucker, demon, etc.) form the near periphery. The distant and outer peripheries include more abstract or contextually conditioned meanings that maintain a weak connection with the main semantic field. Such a multi-level structure demonstrates the flexibility and dynamism of the concept, which evolves along with culture, modifying its value accents.

An important stage of the research is the process of verbalisation, that is, the linguistic representation of the concept. Verbalisation occurs on the cultural level, since culture determines the system of symbols and meanings through which language captures reality [5]. It manifests both lexically and syntactically, from individual words to entire texts where the image of the vampire appears in various semantic and emotional variations. The paradigm of verbalisation is based on the premise that language objectifies perceived reality while simultaneously creating it, forming a particular conceptual worldview.

In this context, the concept "Vampire" is a complex cognitive-emotional formation that combines informational, figurative, and interpretative components [2]. The informational level defines the key cognitive features, representing the vampire as a creature that drinks blood and simultaneously symbolises death and immortality. The figurative component shapes its artistic and cultural appearance, while the interpretative field reflects moral, aesthetic, and emotional evaluations, from horror to romanticisation [4]. This three-component structure creates a holistic concept that integrates rational and irrational layers of human consciousness.

Throughout its evolution, the concept "Vampire" has undergone a transformation from a demonic figure to an aestheticised symbol. Its literary history begins in the European Romantic tradition, where the vampire first appears in Lord Byron's poem *"The Giaour*" and John Polidori's short story *"The Vampyre"* (1819). In the XIX century, thanks to Bram Stoker's novel *Dracula*, the image acquired canonical features: aristocratic appearance, mystical origin, and an inner conflict between the human and the demonic. Later, in the XX century, with the emergence of cinema, the vampire became a symbol of alluring danger and eroticised power, and in the early XXI century, a romantic hero seeking love and moral redemption. Thus, changes in cultural epochs transform not only the content but also the emotional tone of the concept.

From a cognitive-cultural perspective, the concept “Vampire” serves as a bearer of value meanings that reflect collective ideas about good and evil, fear and desire, life and death [3]. Its semantic field is not limited to mythology; it also represents moral and ethical dilemmas characteristic of each culture. In the Ukrainian cultural context, this concept reflects folk beliefs about *upyrs*, representing an archetypal fear of the supernatural and an attempt to comprehend it through language and myth. Therefore, national specificity is manifested in the ways this image is evaluated and verbalised.

The interpretation of the concept in linguistic space is carried out through cognitive generalisation: identifying basic features, metaphors, and symbols that form the semantic field. Cultural linguistics examines the cultural phenomena reflected in language, allowing for the tracing of a people’s spiritual orientations. Through this approach, we can explain why the image of the vampire acquires different connotations in different cultures. In the English-speaking world, it symbolises mysterious attractiveness, while in the Slavic tradition, it represents a dark supernatural threat.

As a result, analysing the concept “Vampire” requires an interdisciplinary approach that combines linguistic, cultural, and cognitive methods. This approach enables not only the description of the semantic structure of the word, but also the identification of the emotional and value potential of the concept and its impact on the recipient’s consciousness. Verbalisation, in turn, becomes not merely a linguistic act but a process of cultural transmission, in which each epoch, language, or author adds its own meanings to the archaic model. The concept “Vampire” is therefore not a static unit, but a living system of emotions, representations, and cultural codes that continues to evolve alongside humanity, while preserving its symbolic power.

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PHYCHOLOGICAL ASPECT OF SELF-ESTEEM

Self-esteem affects how we interact with others. People with high self-esteem tend to build healthier and more harmonious relationships because they are confident in their needs and can express them openly. They are also less prone to excessive dependence on the opinions of others, which helps them avoid toxic relationships. People with healthy self-esteem are comfortable saying ‘no’ and defending their interests without feeling guilty or afraid. Low self-esteem, on the other hand, can cause fear of conflict, difficulty with personal boundaries, or dependence on the approval of others.

The main point is that people with high self-esteem are more likely to achieve success both in life and career. They are more confident in their abilities, willing to take risks, what is very important aspect in running business and unafraid of failure. And conversely, low self-esteem can limit the pursuit of new achievements due to the fear of failure or feelings of inadequacy. People with low self-esteem are often prone to perfectionism. Self-esteem is defined as «an emotional state that reflects an individual's

confidence in their own worth and abilities, which can be influenced by emotional problems such as a lack of self-confidence» [1].

The scientists underline, that self-esteem refers to one's overall evaluation of oneself – the extent to which one values and prizes the self. Self-esteem need not reflect objective reality. Instead, self-esteem is one's subjective evaluation of the self. A person who is overly critical of himself or herself may have a more negative self-evaluation (and thus lower self-esteem) than someone else who, by objective standards, is less competent. Although people with high self-esteem (HSEs) have more favorable self-views than their low self-esteem (LSE) counterparts, LSEs do not necessarily view themselves negatively. Most LSEs evaluate themselves positively, just less positively than do HSEs, or have ambivalent attitudes toward the self. Relatively few LSEs actually dislike themselves [1].

An enduring question is where self-esteem falls on the stability-changeability continuum. There are multiple ways to conceptualize self-esteem change: (1) normative change (age-related trajectories), (2) individual differences in change trajectories (deviations from the average trajectory), (3) rank-order stability (stability of individual differences), and (4) state fluctuations (the ups and downs within persons across moments, days, or weeks; see Robins et al., 2001) [2].

Individual differences in self-esteem development indicate the degree to which self-esteem change deviates from the normative trajectory. Rank-order stability, commonly assessed by test-retest correlations, indicates the degree to which individuals in a population keep their relative positions relative to one another over time. [2]

While science is sure that self-esteem matters, the problem how to enhance self-esteem is not as clear or as simple as it may seem. If someone struggles with low self-esteem, there are some concepts to consider: encourage realistic self-perceptions, have hope that a positive self-image is achievable, understand the causes and consequences of low self-worth, identify the origins of negative self-perceptions, encourage social support to reduce isolation [3].

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CLASSIFICATION OF CONCEPTUAL METAPHORS

Researchers distinguish various classes of conceptual metaphors depending on the criteria underlying their classification.

The specificity of the cognitive “highlighting–hiding” effect determines the division between conventional and novel (original) metaphors [3, p. 139].

Conventional metaphors are based on recurring “systematic correlations between phenomena recorded in our experience” [3, p. 211] and are perceived as habitual ways of conceptualizing reality, manifested in everyday speech and communicative practices. Their imagery becomes eroded, resulting in a loss of expressiveness. Conventional metaphors are characterized by systematicity [3, p. 108].

Novel metaphors, on the contrary, are unexpected; they provide “a new understanding of our experience” [3, p. 61]. For instance, if the metaphorical conceptualization of the concept theory through the concept building highlights such traditionally used elements as the foundation of a theory, the

metaphor is considered conventional. However, in the expression of his theory, which has a thousand small rooms and long winding corridors, the metaphor is interpreted as novel. Scholars note that due to the highlighting–hiding effect, one and the same conceptual metaphor can generate both conventional and novel metaphorical expressions.

According to the nature of the conceptual correlate, metaphors fall into ontological, orientational, and structural types [3, pp. 14–61].

Ontological metaphors provide a means of understanding abstract entities, events, actions, and emotions as objects and substances [3, pp. 29–34]. They are further subdivided into substantive (the so-called "ideal object"), biomorphic or zoomorphic, and anthropomorphic metaphors [2, pp. 281–285].

Anthropomorphic ontological metaphors are also referred to as personifications, as they liken events, objects, and states of affairs to human beings and their characteristics [3, pp. 35–36]. The category of ontological metaphors also includes phenomenal metaphors, which represent crisis as natural forces, natural or man-made phenomena, or cataclysms, and expert metaphors, which conceptualize crisis as a physical or mental illness.

Phenomenal and expert metaphors belong to the ontological type because their correlating entities—like typical ontological entities—are perceived through the senses of the cognizing subject [1, p. 34].

Orientational metaphors organize conceptual systems according to spatial relations, such as up–down, inside–outside, center–periphery, near–far, approach–retract, and others [4, p. 15].

Structural metaphors represent a target concept as composed of other elements, employing a clearly defined concept to structure another. Structural metaphors may include orientational and ontological components. For example, in the metaphor, rational argument is war, the structure of the concept argument is organized according to the structure of the concept war:

participants (communicators → opponents);

components (argument → position; disagreement → opposing position; debate strategy → war strategy);

stages (beginning: expression of viewpoints → opposing sides; middle: argumentation → attack/defense; end: acceptance/rejection of arguments → capitulation/victory);

result (disagreement leading to agreement/disagreement → attack leading to counterattack or retreat);

goal (persuasion of the opponent → victory) [4, pp. 14–61].

In terms of axiological marking, depending on the type of compared denotatum and the context, metaphors may be neutral or emotionally evaluative, expressing positive or negative attitudes of the discourse subject toward the referent [1, p. 36].

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THE ROLE OF OUT-OF-STUDY ENGLISH USE IN DEVELOPING SPEAKING SKILLS

English has become a global language of communication, business, and culture. As worldwide interaction expands, learners increasingly acquire English not only in formal classrooms but also through

daily exposure beyond studying. Research by Pia Sundqvist (2009), Tabitha Dayanand Soans (2022), and Widi Andewi & Lidya Ayuni Putri (2025) collectively demonstrates that English use outside the classroom plays a vital role in improving learners' oral proficiency, vocabulary growth, confidence, and motivation.

Sundqvist's Swedish study of eighty ninth-grade students revealed that extramural English—activities such as gaming, reading, watching films, and surfing the internet—correlates strongly with both vocabulary size and speaking ability. Productive and interactive activities, like online games and internet communication, produced higher gains than passive ones such as listening to music. Importantly, the research found that extramural practice benefits learners regardless of socioeconomic background and can reduce the traditional gap between formal learning and authentic communication.

Soans (2022) complements this finding by emphasizing the social and personal importance of speaking English in daily life. She highlights that speaking is the core of communication, essential for academic success, career development, and self-expression. According to her, regular practice and active listening build vocabulary, pronunciation, and fluency, while formal and informal speaking contexts help individuals form relationships and achieve professional goals. Mastery of spoken English serves as a "passport" to global opportunities and cultural exchange.

Andewi & Putri (2025) extend these ideas through a narrative inquiry with Indonesian university students, showing how learners use English in real-life contexts such as social media, online videos, and peer discussions. Their participants reported that using English outside class increased confidence, reduced anxiety, and supported personal motivation. The study also connects these experiences to Self-Determination Theory, noting that intrinsic motivation—learning for enjoyment and personal growth—sustains language use more effectively than external pressure. Teachers are therefore encouraged to integrate students' out-of-class experiences into classroom instruction and to design activities reflecting authentic communication.

Together, these studies underline a common conclusion: English learning does not stop at the classroom door. Interaction with the language in daily life—through media, technology, or social contact—develops communicative competence more effectively than traditional instruction alone. Encouraging learners to engage with English in meaningful, real-world contexts cultivates fluency, expands vocabulary, and enhances self-efficacy. Future teaching should bridge formal education with students' digital and social environments, transforming everyday English use into a powerful tool for lifelong language learning.

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THE ROLE OF CLIL IN DEVELOPING ENTREPRENEURIAL THINKING WITHIN BUSINESS ENGLISH INSTRUCTION

Contemporary transformations in the labour market require the training of specialists who are capable of thinking economically, making informed decisions in conditions of uncertainty, and communicating with partners from different countries. In this context, Business English is not only a means of intercultural communication, but also a tool for developing economic competence. Proficiency in professional vocabulary and the ability to understand financial reports, business analytics and

economic arguments in English create a new level of readiness for applicants to enter the global professional environment.

Integrating English language learning with Economics courses helps students develop a holistic view of economic processes and systematic analytical skills. The use of business cases, business simulations and project-based learning when teaching Business English course provides a situational approach where students work on real economic problems: investment appraisal, budget planning, analysis of competitive strategies or marketing decisions. Such tasks contribute to the formation of analytical thinking skills and an understanding of the interrelationships between linguistic and economic information.

An important component of the development of economic thinking is the ability to interpret data presented in the form of tables, graphs, and statistical reports in English. Working with authentic materials — financial press releases, reports from international companies, analytical reviews — allows students to develop the ability to see patterns in economic processes, critically evaluate information, and make informed conclusions. Such exercises are interdisciplinary in nature, as they combine language practice with economic analysis, teaching students to think like economists but communicate like international professionals.

Teaching business English in an economic context should be based on the principle of Content and Language Integrated Learning (CLIL), which involves the simultaneous development of language and subject-specific competences. The implementation of this principle ensures not only the acquisition of vocabulary, but also the formation of an economic worldview based on a practical understanding of the market, finance, management and business planning.

An example of the practical implementation of this approach is the teaching of the discipline ‘Fundamentals of Entrepreneurship’ for first-year students at Vasyl’ Stus Donetsk National University, where the teaching material is integrated on the basis of cooperation with teachers from Dmytro Motornyi Tavria State Agrotechnological University. The course uses elements of Business English course, in particular, the introduction of authentic terms and expressions without translation (business model, value proposition, target audience, cash flow, customer journey, stakeholder analysis, etc.), which are organically woven into the lecture material and practical tasks. This approach allows students not only to master basic economic concepts, but also to immediately develop English-language professional thinking that corresponds to the realities of the international business environment.

Therefore, the formation of economic thinking through the means of Business English course is an effective direction for modernising the content of professional education. This approach contributes to the development of complex competencies, integrates knowledge from various fields, and ensures the readiness of future specialists to work in the conditions of a globalised economy.

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PHRASAL VERBS: DIFFERENTIATION, CLASSIFICATION, AND TRANSLATION

Phrasal verbs (PVs) remain one of the most complex issues in modern English philology. The study of their semantics and function is crucial for understanding the human factor in language. Consequently, analyzing their communicative-cognitive features and semantic role in shaping the linguistic worldview is essential for describing the interaction and transformations of their components. The lexico-semantic aspect is primary in distinguishing PVs from simple verbs.

J. Povey defines a PV as a combination of a simple verb and an adverbial post-positive (particle), functioning as a single semantic and syntactic unit. A common, though not universal, criterion for lexical unity is replacement by a simple verb (e.g., call up – telephone; put off – postpone). However, many PVs are synonymous only with other phrases (break down – stop functioning).

A key feature of PVs is idiomaticity: the meaning of the combination often cannot be derived from the meanings of its individual elements (e.g., bring up – educate; give up – stop doing).

The position of the adverbial particle relative to the object is a defining trait. If the object is a noun, the particle can often be placed before or after it (Call up her brother or Call her brother up). However, if the object is a pronoun, it always occupies the interposition (She took her coat and put it on). The final position typically carries greater lexical load, and longer objects usually occupy the final position.

L. P. Smith considered PVs a highly characteristic feature of English, frequently used in conversational language to add expressiveness and clarity (e.g., the expressive This weather gets me down vs. the neutral This weather depresses me).

For non-native speakers, PVs present considerable difficulty. The main challenges include:

The vast number and variety of English phrasal verbs.

The prevalence of figurative (transferred) meaning.

The possibility of the post-positive being separated by the object.

To differentiate PVs from simple verbs, R. Courtney's classification is often used, which includes:

Idiomatic expressions (e.g., give up).

Verbs used only with a specific preposition/adverb (e.g., rely on).

Combinations where the adverb merely intensifies the simple verb (e.g., hurry up = hurry).

PVs that always take "it" as an object (e.g., jump to it).

Reflexive PVs (e.g., pride yourself on).

Key criteria for distinguishing a PV from a simple verb with a particle are: stress on the particle, the ability of the particle to be moved to the end of the clause, and the impossibility of the simple verb being separated from the particle by an adverb.

The stylistic aspect is crucial in translation. These units are normally divided into neutral combinations (used in all styles) and expressive combinations. A translator must consider the register (e.g., an emotional dialogue vs. a formal contract).

Beyond style, pragmatic adaptation is necessary to achieve communicative goals, accounting for the different linguistic experiences, mentalities, and background knowledge of the original and translated text recipients. Accurate translation heavily depends on context and often requires a transformational translation model when a literal rendering is inadequate.

It has been found that the translation of phrasal verbs primarily employs lexico-semantic transformations, namely: specification (concrete translation), generalization, selection of a variant equivalent, and contextual substitution. However, most often, the translator finds a lexical equivalent —a simple verb in the target language that most fully conveys the meaning of the phrasal verb.

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ANGLICISMS IN THE PROFESSIONAL LANGUAGE OF PHYSICIANS IN UKRAINE

With the development of national languages, German, English, and French became dominant in medicine. However, a globalised society chose English, which, like Latin, formed a single, leading communicative space for interaction between countries. Globalisation trends in the world market for medical services have led to the integration of Ukraine's healthcare sector into international cooperation and, as a result, to the appearance of anglicisms that have carved out a niche in the language system.

Progress in any field, including medicine, is accompanied by the genesis of new words, which gradually enter other languages as loanwords. Since borrowings are one of the ways to enrich the language, it is essential to understand the factors influencing interlingual interference in the ever-changing reality. The study aimed to analyse the influence of the English language on the emergence of anglicisms in Ukrainian. It focused on the category of nouns, notably screening, cluster, check-up, case, gaslighting, abuse, stretching, monitoring, patch, checklist, and sequencing, which are widely accepted in medical settings and have already undergone the process of borrowing connected with adaptation to the

orthographic, phonetic, and grammatical standards of the Ukrainian language. A descriptive method based on a survey in which 58 students of Bukovinian State Medical University participated. The questionnaire contained pairs of words, i.e., anglicisms and their Ukrainian equivalents, as well as answer options for respondents to indicate the reason for their choice of word, such as euphony, explicitness, up-to-datedness, etc.

The survey results showed the following ratio of anglicisms to Ukrainian equivalent: screening 57,1% vs 42,9%, cluster 10,7% vs 89,3%, check-up 48,2% vs 51,8%, case 40% vs 60%, gaslighting 37,5% vs 62,5%, abuse 52,8% vs 47,2%, stretching 47,4% vs 52,6%, monitoring 86% vs 14%, patch 42,1% vs 57,9%, checklist 73,7% vs 26,3%, and sequencing 39,3% vs 60,7%. The data obtained revealed that anglicisms are comprehended and perceived as prestigious and easy to pronounce. Moreover, some English terms lack full-fledged Ukrainian equivalents, are shorter and more convenient for communication, and facilitate common understanding in the professional environment, which, in turn, seeks accuracy and standardisation of terminology. However, those with the lowest percentage attracted considerable interest. Still, respondents noted that these terms require clear explanations, since the modernity of a word does not necessarily make it understandable, and they should not be used without understanding their exact meaning. Overall, the results demonstrate that the integration of anglicisms into the Ukrainian language environment occurs depending on frequency of use, educational context, and the availability of Ukrainian equivalents.

Thus, the emergence of anglicisms is influenced by both extralinguistic (scientific and technological advancements) and intralinguistic (the ability of a language to coin new terminological units), which explain why anglicisms become established and occupy their niche in the medical professional vocabulary of Ukrainian physicians. Prospects for further research lie in tracking transcoding processes in interlingual transferring.

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DIFFICULTIES IN THE ACQUISITION OF TECHNICAL TERMINOLOGY

In the field of English for Specific Purposes, one of the most persistent challenges that learners face is the acquisition of technical terminology. Unlike general vocabulary, technical terms are specialised, often discipline-bound, and characterised by low frequency and high conceptual density. Studies highlight that students struggle with such vocabulary because of its complexity, abstractness, and lack of prior familiarity.

First, the nature of technical terminology creates inherent obstacles. These lexical items typically refer to domain-specific concepts. They often have complex morphological structure, such as compounds or affixed formations, and they seldom appear in general English use. Researchers indicate that technical terms present the highest cognitive load because learners cannot rely on everyday context or intuitive meaning to infer them. Additionally, the abstractness of many technical terms means learners must understand both concept and context simultaneously, which increases learning difficulty.

Second, limited exposure and infrequent occurrence of technical vocabulary compound the challenge. Terms specific to professional fields appear sparsely in general language input, which means learners receive fewer meaningful encounters and less chance for incidental learning. A study of technical students showed that without deliberate focus and repeated exposure, technical vocabulary remains weakly consolidated. Learners may recognise a term superficially but fail to retain or use it productively in writing or discourse.

Third, there are strategic and pedagogical challenges. Many students lack effective techniques tailored to technical vocabulary, such as morphological analysis, collocation practice, or domain-specific learning. Research shows that traditional vocabulary strategies – memorisation or dictionary look-up – are often inadequate for technical vocabulary, leading to low retention and frustration. Teachers must

therefore employ specialised interventions, such as term-mapping tasks, glossaries embedded within discipline texts, and repeated authentic exposure, to support students.

Fourth, learners often face difficulties when transferring technical terminology into active use. Even when recognition is achieved, productive use in speech or writing remains problematic. For example, learners in technical programmes reported difficulty retrieving technical terms during tasks despite prior exposure via online courses. This retrieval failure can reduce confidence and impair performance in professional contexts.

Finally, these difficulties have significant implications for technical vocabulary instruction. Learners' professional advancement may be constrained if they do not master the vocabulary central to their discipline. In response, educators try to integrate technical vocabulary systematically into course design, scaffold exposure via domain-specific texts and tasks, and provide frequent retrieval practice, context-rich tasks, and peer-collaborative work. Effective vocabulary learning demands not only high-quality input but also strategic training in how to learn and use technical terms.

In conclusion, the acquisition of technical terminology poses major challenges due to term complexity, low frequency input, inadequate learning strategies, and difficulty in productive use. Overcoming these difficulties requires a deliberate instructional focus on terminology knowledge, reinforced exposure, purposeful learning strategies, and guided opportunities for use.

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SELF-LEARNING IN EFL AND PROGRESS MONITORING

In the contemporary landscape of language education, self-learning in English has emerged as a powerful pathway for learners across the globe. With the wealth of resources available online – such as mobile apps, digital platforms, and virtual communities – individuals are now empowered to set personal goals, choose materials, and tailor their own learning trajectories. However, one of the most significant challenges that self-learners face is measuring and monitoring their progress effectively. Without external assessments or a formal classroom environment, learners can easily lose direction or fail to recognise how far they have come.

Research on self-regulated learning underscores the importance of three core phases: goal-setting, monitoring progress, and self-assessment. Initially, learners need to define clear, measurable objectives – such as mastering 100 new vocabulary items, improving spoken fluency, or achieving a specific CEFR level. Once those goals are set, the monitoring phase begins. Effective monitoring can take several forms: keeping a language journal, using spaced-repetition flashcards, recording speaking sessions, or entering data in a tracking system to reflect on performance. Technology now offers sophisticated tools for self-learners, from digital dashboards to automated analytics that visualise learning trends.

Following the monitoring phase, self-assessment plays a critical role. Learners evaluate their progress against their initial goals, reflect on what strategies worked, and adapt their plan accordingly. This creates a cyclical process of continuous improvement. When learners engage actively in all three phases – planning, monitoring, evaluating – they develop autonomy and become more motivated in their language learning.

Another key aspect to consider is the variety of measurable indicators that can signal genuine progress. These include: increased complexity and length of written texts, reduced hesitation in speaking, improved comprehension of authentic audio/video content, and higher scores in periodic assessments. Tools such as digital portfolios or self-assessment rubrics help learners visualise growth and maintain motivation. In addition, regular testing – both formal and informal – provides concrete data that validate "feeling better" into tangible evidence of improvement.

For educators and learners alike, the implications of effective progress monitoring are substantial. Teachers may guide learners in selecting appropriate self-assessment tools, designing personalised monitoring templates, and offering constructive feedback on the self-learning process. For students

engaged in self-learning, cultivating the habit of regular tracking and reflection turns vague goals into structured action and ultimately into actual language proficiency.

In conclusion, English self-learning offers extraordinary flexibility and potential – but only when accompanied by systematic progress monitoring. By integrating goal-setting, careful monitoring, and reflective self-assessment, self-learners can maintain focus, measure improvement, and adapt strategies to reach higher levels of competence. In doing so, they gain not only language skills but also lifelong learning habits transferable beyond English and across disciplines.

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TRACKING ADVANCEMENT IN EFL LEARNING BY MEANS OF LEARNERS' SELF-ASSESSMENT

As a student learning a foreign language, I've realized that consistently monitoring my progress is one of the most powerful methods for staying aligned with my learning goals. It helps me maintain concentration and provides insight into both my strengths and the aspects that need further work. By tracking my achievements, I can clearly see how far I've come in my language-learning journey and make necessary adjustments to continue improving.

One of the main techniques I use to evaluate my development is self-assessment. This method is especially valuable because it encourages me to pause and honestly examine my performance across key skills – speaking, listening, reading, and writing. Regular self-assessment increases my awareness of which skills are improving and which still require extra effort. Through this process, I've discovered that my reading comprehension is quite strong, but I need to dedicate more time to enhancing my speaking fluency. This realization helps me stay focused and prioritize my learning effectively.

Another useful strategy for monitoring my progress involves quizzes and tests. These assessments give me immediate feedback on specific areas such as grammar, vocabulary, and comprehension. Each test serves as a checkpoint, helping me determine what I've mastered and what still needs attention. When I notice recurring mistakes, I make sure to revisit those topics in more detail. Beyond measuring knowledge, these quizzes boost my confidence by providing concrete evidence of improvement.

In addition to self-assessment and quizzes, I regularly use language-learning apps. These tools are extremely helpful because they provide structure and allow me to monitor my progress through data. Most apps offer exercises in different areas – listening, grammar, speaking, and vocabulary – and include built-in progress trackers. I can easily review how much my vocabulary has expanded or how my listening accuracy has improved. Seeing this measurable progress keeps me motivated and makes my goals feel more attainable.

Feedback from teachers and language partners also plays a crucial role in my learning journey. I often practice with a native-speaking partner, which helps me engage in real-life communication. My partner offers useful corrections on pronunciation, phrasing, and natural expressions. Similarly, my instructor's professional feedback helps me refine my writing and speaking skills by pointing out subtle mistakes that I might overlook.

Overall, by evaluating my progress regularly, I stay disciplined and focused on achieving my goals. Every small success – whether it's mastering a new word list or engaging in a longer conversation – fuels my enthusiasm and reinforces my dedication. Monitoring my progress not only keeps me motivated but also deepens my appreciation for the learning process itself. Therefore, consistent progress tracking has become an essential element of my language-learning experience, ensuring I remain committed, self-aware, and driven toward continuous improvement.

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DISTORTION OF COGNITIVE ABILITIES UNDER THE INFLUENCE OF VERTICAL VIDEOS

In recent years, vertical videos have become a main format for content on apps like TikTok, Instagram, and YouTube Shorts. These short clips are clearly made to be fast, emotional, and very easy to watch. It seems this design is changing how we perceive and process information. The vertical screen focuses our attention on the center and limits what we see around the edges. This makes it easy to see the main object but harder to understand the full context. We believe that when using this format too much, it might start to affect our visual memory, focus, and thinking skills.

It also feels obvious that these apps are designed to be addictive. They seem built to keep users scrolling by giving them quick, constant rewards. Each new video feels like a small, exciting discovery, and it's easy to fall into a cycle. In our experience, this is where we are always looking for the next piece of content, which makes it very hard to put the phone down. This design doesn't feel accidental; it feels engineered to hold our attention for as long as possible.

From our perspective, constant use of this fast and dynamic content can lead to shorter attention spans and "shallow" information processing. When we get used to 15-second videos, our brains start to expect this fast stimulation all the time. We've investigated that it is much harder to focus on longer or more complex things, like reading a book or listening to a long lecture. This is what some people call “clip thinking,” where our thoughts become more fragmented and reactive instead of deep and analytical. Clip thinking is a modern style of thinking driven by very short video clips. It is characterized by fragmentation, speed and superficiality. In other words, people with clip thinking process information in fast, disconnected chunks. For example, when someone watches many quick clips (like TikToks or Instagram Reels), their mind jumps rapidly from one idea to the next instead of following a long, logical argument. In this mode, people focus on short, catchy pieces of information and favors quick images over deeper explanations [1].

Clip thinking can reduce some important cognitive skills. When people watch many short videos, their brain starts to expect quick rewards and fast emotions. Because of this, it becomes difficult to keep attention for a long time. People also lose the habit of thinking deeply and carefully. It gets harder to understand long texts or remember detailed information. In general, watching too many short clips can harm focus, memory, and logical thinking [2].

To conclude, while vertical videos are a fun source of entertainment and quick information, we suggest that their design can encourage distraction and impatience. It is important for us to be aware of these effects. To avoid these cognitive problems, we should probably try to balance our time. We can still enjoy short videos, but we also have to find time for activities that build deep focus, like reading, learning a new skill offline, or just having long conversations without digital interruptions.

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INTERTEXTUAL VERBALIZATIONS OF THE CONCEPT BERLIN WALL (BASED ON GERMAN-LANGUAGE MULTIMEDIA QUOTATIONS)

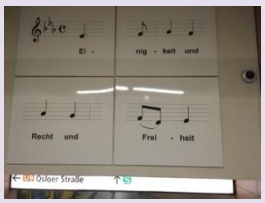
The aim of the study is to determine the role of reproducible (recurrent) quotations presented in a multimodal format in constructing the linguistic and cultural concept of the BERLIN WALL in the minds of German speakers.

The relevance of a multimodal approach to linguistic phenomena in linguistics is due to the rapid expansion of the use of verbal texts in public spaces, particularly on architectural objects, monuments, memorial plaques, information carriers, in museums, and street art [2].

Contemporary urban space demonstrates the expansion of the concept of quotation beyond the verbal sphere. Multimodal quotations in the urban landscape function as materialized carriers of cultural memory and intertextual practices.

The Berlin Wall stands not only as a physical barrier that divided the city, but also as a powerful symbol of political and ideological division that shaped the identity of generations in the GDR and the FRG. After its fall, it became a key element of collective memory, stimulating dynamic reflection on trauma, unity, and the reconstruction of the image of a "new Germany." In this sense, according to Huissen, Berlin's urban space functions as an "urban palimpsest" – a multi-layered text in which the past is constantly being rewritten in new cultural and political contexts [1, p. 72–76].

Multimodal quotations related to the Berlin Wall combine linguistic, visual, spatial, and contextual levels with varying degrees of intertextuality, as evidenced by multimodal quotations in Berlin's urban space (U-Bahn):



P*ic. 1. Quote at the metro station Brandenburger Tor/Pic. 2 Quote at the metro station Osloer Straße*

The installation in Pic. 1 contains legendary phrases in mosaic order: "Niemand hat die Absicht, eine Mauer zu errichten." (Walter Ulbricht) "Tear down this wall!" (Ronald Reagan) and others, with the typography, architectural space, and movement of the subway escalator creating a dynamic reading effect as the phrases unfold gradually, "like history before your eyes," illustrating the dynamics of the entire history of the wall - from its construction in 1961, through the Cold War, to the destruction of this symbol of the division of the German people in 1989.

The dominance of the nonverbal component in a multimodal quotation can be observed in another artifact (Pic. 2). The text of the German national anthem is represented only by the first few words, but the visual metaphor of the musical accompaniment (musical correlates) creates a multichannel perception and enhances the effect of Hoffmann von Fallersleben's text "Einigkeit und Recht und Freiheit." The key lexeme is Einheit, which creates a conceptual polyphony with the symbolic act of destroying the wall as a restoration of unity.

Consequently, specific linguistic and speech units such as multimodal quotations in urban space have their own special niche in the construction of linguistic and cultural concepts such as the BERLIN WALL due to intertextual connections and multichannel perception by the recipient.

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GERMAN LANGUAGE SECTION

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EINSATZ VON KI-TECHNOLOGIEN IN DER LEBENSMITTELINDUSTRIE

Künstliche Intelligenz (KI) verändert verschiedene Branchen, und die Lebensmittelindustrie bildet da keine Ausnahme. Bei der Entwicklung neuer Lebensmittelprodukte wird KI zu einem unverzichtbaren Werkzeug für mehr Innovation, Effizienz und Produktanpassung. Hier sind einige Beispiele dafür, wie KI diesen Sektor beeinflusst:

1. Entwicklung neuer Rezepturen
2. Optimierung von Geschmack und Textur
3. Produktpersonalisierung
4. Verbesserung der Lieferkette und Nachhaltigkeit
5. Innovation bei alternativen Produkten
6. Virtuelle Markttests
7. Innovationen bei der Kennzeichnung und Verpackung

In Verarbeitungsbetrieben hat sich die künstliche Intelligenz von einfachen Automatisierungssystemen zu intelligenten Ökosystemen entwickelt, die zur Selbstoptimierung fähig sind. Zu den bekannten Anwendungen gehören:

Prognose-basierte Qualitätskontrolle

Maschinelle Bildverarbeitungssysteme analysieren Produkte in Echtzeit und erkennen:

– Abweichungen in Farbe, Textur und Form mit mikroskopischer Genauigkeit

– Organische und anorganische Verunreinigungen, die mit bloßem Auge nicht erkennbar sind

– Modelle zur Zustandsverschlechterung, die eine genaue Vorhersage der Verwendungsdauer ermöglichen

Optimierung thermischer Prozesse

Spezialisierte Algorithmen passen die Parameter für die Zubereitung, Pasteurisierung und Sterilisierung an:

– Senkung des Energieverbrauchs um 15 %

– Verbesserung der Erhaltung von Nährstoffen um 20 %

– Vollständige Standardisierung des Endprodukts

Künstliche Intelligenz ermöglicht es, Probleme der Lebensmittelsicherheit vorherzusagen, indem sie:

- Prognosemodelle für Zustandsverschlechterungen erstellt: Algorithmen, die die tatsächliche Nutzungsdauer unter Berücksichtigung mehrerer Variablen berechnen

- Anomalien erkennt: Systeme, die Abweichungen in Prozessen erkennen, die die Sicherheit gefährden könnten

- Dynamische Risikoanalyse: Kontinuierliche Bewertung der Wahrscheinlichkeit einer Kontamination in Echtzeit

Allerdings müssen auch die Risiken betont werden: Datenschutz und Verbrauchertransparenz, Abhängigkeit von Technologie, Arbeitsplatzverluste und Strukturwandel, Ethik und Fairness.

Zusammenfassend lässt sich sagen, dass künstliche Intelligenz die Entwicklung neuer Lebensmittelprodukte revolutioniert, indem sie die Herstellung gesünderer, personalisierter und nachhaltiger Lebensmittel ermöglicht. Durch den Einsatz von KI-Fähigkeiten kann die Lebensmittelindustrie effektiver auf sich ändernde Marktanforderungen und globale Herausforderungen wie Klimawandel und Ernährungssicherheit reagieren.

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KÜNSTLICHE INTELLIGENZ IN DER CNC-BEARBEITUNG: INNOVATION FÜR DIE PRODUKTION DER ZUKUNFT

Bei der CNC-Bearbeitung ging es schon immer um Präzision. Man gibt einen Entwurf ein, die Maschine führt ihn aus, und man erhält ein Teil, das den Spezifikationen entspricht. Werkzeuge nutzen sich ab, Materialien verhalten sich unterschiedlich, und hundert kleine Variablen können einen aus der Bahn werfen. KI soll die Arbeit erleichtern, nicht die Maschinenbediener ersetzen.

Hier sind einige Beispiele dafür, wie KI einen bedeutenden Einfluss auf CAM-Software und Programmierung hat und die Effizienz, Präzision und Automatisierung in der CNC-Bearbeitung verbessert [2]:

1. Automatisierte Merkmalserkennung
2. KI-gestützte Assistenten, Copiloten und Chat-Schnittstellen
3. KI-gestützte Entscheidungsunterstützung
4. KI-gestützte Plug-ins und Software-Erweiterungen [2]

Daher können wir sagen, dass KI für die CNC-Bearbeitung viel praktischer ist. Es geht darum, die Probleme zu lösen, mit denen Maschinenbediener täglich konfrontiert sind, und sicherzustellen, dass die Spindel weiterhin saubere, gleichmäßige Teile schneidet. Hier zeigt sich bereits der Nutzen:

Vorhersage und Überwachung des Werkzeugverschleißes. Anstatt zu raten, wann ein Schaftfräser stumpf wird, analysieren KI-Modelle das Spindeldrehmoment, Vibrationsdaten und sogar akustische Signale. Das System erkennt, wenn der Fräser kurz vor dem Ausfall steht, bevor er die Oberflächenqualität beeinträchtigt [1].

Adaptive Vorschub- und Geschwindigkeitssteuerung. Bei der traditionellen Bearbeitung werden festgelegte Parameter verwendet, aber Materialien sind nicht immer einheitlich. KI ermöglicht es Maschinen, Vorschub und Geschwindigkeit in Echtzeit anzupassen, um einen optimalen Schnitt zu gewährleisten [1].

Prozesssimulation und digitale Zwillinge. Bevor Sie ein Teil bearbeiten, simulieren KI-gesteuerte digitale Zwillinge Werkzeugwege, Belastungen und mögliche Kollisionen. Das ist so, als würden Sie Ihren G-Code in einer sicheren virtuellen Umgebung testen, bevor Sie ihn auf echtem Material anwenden [1].

Automatisierte Qualitätsprüfung. KI in Verbindung mit Bildverarbeitungssystemen kann Abmessungen, Oberflächenrauheit oder Defekte direkt an der Maschine überprüfen. Anstatt stundenlang auf CMM-Berichte zu warten, erkennen Sie Probleme sofort [1].

Die Einführung künstlicher Intelligenz in CNC-Werkzeugmaschinen erfordert jedoch auch bestimmte Kenntnisse und Fähigkeiten seitens des Bedieners. Die Bediener müssen in der Lage sein, fortschrittliche Werkzeuge und Algorithmen der künstlichen Intelligenz effektiv einzusetzen, um das gesamte Potenzial der CNC-Werkzeugmaschinen auszuschöpfen. Daher ist es wichtig, dass die Mitarbeiter eine entsprechende Schulung für den Betrieb von CNC-Werkzeugmaschinen unter Verwendung künstlicher Intelligenz absolvieren.

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DER TECHNOLOGISCHE FORTSCHRITT IN DER BAUINDUSTRIE

Der technologische Fortschritt hat sich unmittelbar auf die Bauindustrie ausgewirkt. Innovationen werden in allen Bereichen eingeführt, führen zu einer höheren Produktivität, senken die Kosten, steigern die Effizienz der Arbeitsabläufe und verbessern die Qualität der Arbeitsergebnisse. Flexibilität und Innovationsfähigkeit gegenüber neuen Bedingungen, die Fähigkeit, alle Aufgaben der Mitarbeiter zu erfüllen, und effektive Lösungen für die Umsetzung und Erhaltung zu finden.

In Deutschland wird der 3D-Druck für den Bau von Wohnhäusern eingesetzt, wodurch die Bauzeit verkürzt und die Kosten gesenkt werden können.

Die 3D-Drucktechnologie hat Vorteile wie eine Verkürzung der Bauzeit und eine Senkung der Arbeitskosten, erfordert jedoch spezielle Ausrüstung und eine präzise Planung. Das Hauptziel des Projekts ist die Beschleunigung des Wohnungsbaus und die Optimierung der Kosten.

Die Technologie basiert auf der automatisierten Erstellung von Wänden durch das Auftragen von Baumaterialien in Schichten nach einem digitalen Plan.

Für das Projekt sind drei Standardformate für Gebäude vorgesehen, die es ermöglichen, sechs bis zwölf Wohnungen in einem Haus unterzubringen. Die Fläche der einzelnen Wohnungen beträgt etwa 46 bis 89 Quadratmeter.

Die Wiederholbarkeit architektonischer Lösungen vereinfacht die Prozesse und verkürzt die Bauzeit. Darüber hinaus wird spezieller Beton mit niedrigem Kohlenstoffgehalt verwendet, der den modernen ökologischen Anforderungen entspricht.

Der Druckprozess von Gebäuden spart viel Zeit. Die Arbeiten werden parallel ausgeführt, und ein Quadratmeter Wand wird in fünf Minuten geformt. Dank dieser Technologie können Gebäude in wenigen Wochen errichtet werden.

Die wichtigsten Vorteile dieser Technologie:
kürzere Bauzeit;
geringere Arbeitskosten;
rationelle Nutzung von Materialien;
Wiederholbarkeit von Projekten;
Präzision bei der Planung.

Standardisierte Formate ermöglichen eine hohe Wiederholbarkeit von Projekten und eine langfristige Bauplanung. Darüber hinaus bietet die digitale Planung die Möglichkeit, technische Lösungen bereits in der Projektphase zu integrieren, was zu einer optimalen Anordnung der Versorgungsleitungen beiträgt.

Trotz der Vorteile gibt es auch gewisse Einschränkungen:
keine Massenanwendung;
hohe Präzision bei der Planung erforderlich;
spezielle Materialien;
Bedarf an Spezialausrüstung und geschultem Personal.

Darüber hinaus gibt es technische Herausforderungen im Zusammenhang mit der Kombination von gedruckten Elementen mit anderen Bauprozessen – der Installation von Versorgungsnetzen, Fenstern, Türen und Decken. Dies erfordert eine sorgfältige Planung und Abstimmung zwischen verschiedenen Fachleuten, was den Prozess erschwert.

Der 3D-Druck verbreitet sich allmählich auch in anderen Regionen der Welt. Ein Beispiel dafür ist der Bau einer Bildungseinrichtung in der Ukraine, wo für die Errichtung der Wände ebenfalls die Methode des großformatigen 3D-Drucks zum Einsatz kommt.

Die Technologie kann nicht nur im Wohnungsbau, sondern auch bei sozialen Einrichtungen eingesetzt werden. Dies ist besonders relevant für die schnelle Wiederherstellung und Modernisierung der Infrastruktur, wo es auf die Geschwindigkeit des Baus und die optimale Nutzung von Ressourcen ankommt.

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DIE AUSWIRKUNGEN DES KRIEGES AUF DIE ÖKOLOGIE DER UKRAINE

Der Krieg ist nicht nur eine humanitäre und wirtschaftliche Katastrophe für die Ukraine, er fügt auch der Ökologie unseres Landes enormen Schaden zu. Seine Folgen für die Umwelt sind weitreichend und langfristig: Durch den Krieg werden Böden, Gewässer und Luft verschmutzt und beschädigt, die biologische Vielfalt der Natur wird zerstört.

Die Kampfhandlungen haben weite Gebiete der Ukraine in Zonen der ökologischen Degradation verwandelt. Die Bewegung von Militärfahrzeugen, der Bau von Befestigungsanlagen und die Verminung führen zur Zerstörung fruchtbarer Böden und zur Veränderung des Reliefs. Auch durch ständige Munitionsexplosionen wird der Boden mit giftigen Stoffen – Blei und Kupfer – angereichert. All dies macht den Schwarzerde Boden für die Bewirtschaftung ungeeignet, und die auf diesem Land angebauten Produkte können eine Gefahr für die menschliche Gesundheit darstellen.

Die Explosionen, Brände, der Einsatz schwerer Militärausrüstung und die Verwendung von Generatoren führen zu einer kolossalen Zunahme der Treibhausgasemissionen. Dies ist nicht nur ein lokales Problem, sondern auch ein Beitrag zum globalen Klimawandel.

Nicht weniger schwerwiegend ist das Problem der Verschmutzung der Wasserressourcen. Die Zerstörung von Dämmen, Wasserversorgungssystemen und Abwasseranlagen, insbesondere bei der Sprengung des Wasserkraftwerks Kachowka im Juni 2023, führte zur Überflutung riesiger Gebiete, zum Fischsterben und zur Auswaschung chemischer Substanzen in den Dnipro und das Schwarze Meer. Dies hat das natürliche Gleichgewicht der aquatischen Ökosysteme gestört.

Die Artillerieschläge verursachen massive Brände in Wäldern und Steppen, bei denen Tausende von Tier- und Pflanzenarten sterben, von denen die meisten in der Roten Liste der Ukraine aufgeführt sind.

Die Präsenz russischer Kriegsschiffe im Schwarzen Meer und die Ölfreisetzungen führen zum Massensterben von Fischen und Delfinen. Spezialisten des Nationalen Naturparks „Tuzla-Liman-Seen“ schätzen die ungefähre Zahl der getöteten Delfine auf 50 Tausend.

Der Krieg hat auch große Auswirkungen auf die Atmosphäre. Explosionen, Brände in Treibstofflagern und die Zerstörung von Industrieanlagen verursachen Emissionen von schädlichen Gasen, Schwermetallen und Staub, was sich nicht nur negativ auf die Natur, sondern auch auf die menschliche Gesundheit auswirkt. Kampfhandlungen in der Nähe von nuklearen Anlagen wie den Kernkraftwerken Saporischschja und Tschernobyl schaffen Risiken einer radioaktiven Verseuchung, die weit über die Grenzen der Ukraine hinausreichen.

Der geschätzte Betrag der der Umwelt zugefügten Schäden beläuft sich nach Berechnungen des ukrainischen Umweltministeriums auf über 250 Milliarden Hrywnja.

Die Folgen des Krieges für die Ökologie werden nach dem Ende der Kampfhandlungen nicht verschwinden. Die Wiederherstellung der Natur wird Jahrzehnte dauern. Daher ist die Frage der ökologischen Sicherheit nicht nur ein internes Problem der Ukraine, sondern auch eine Bedrohung für die globale ökologische Sicherheit und erfordert daher die Aufmerksamkeit der internationalen Gemeinschaft.

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DIGITALE NECHNOLOGIEN VERÄNDERN DIE EISENBAHNBRANCHE

Wer hätte gedacht, dass die Eisenbahn einen solchen technologischen Durchbruch erzielen könnte? Eine Branche, die als eine der traditionellsten galt, begann plötzlich, neue Technologien aktiv zu erforschen und sie rasch in die Praxis umzusetzen.

Zu den Trends, die den Markt für Logistiklösungen in naher Zukunft verändern werden, zählen insbesondere die aktive Digitalisierung des Kundenerlebnisses, die Umstellung von B2B-Unternehmen auf E-Commerce sowie die Nutzung von Big Data und künstlicher Intelligenz. Innerhalb einer Reihe von Unternehmen entsteht ein echtes elektronisches Gehirn, das eine präzise und koordinierte Arbeit bei der Lieferung von Fracht in allen Phasen gewährleistet – vom Abschluss des Vertrags bis zum Eingang der Produkte im Lager des Empfängers. Die Arbeit des elektronischen Gehirns ist jedoch ohne ein Nervensystem, das alle Komponenten miteinander verbindet und eine einheitliche Informationslandschaft bildet, nicht möglich.

Einige Eisenbahnbetreiber haben sich für SAP S/4HANA als „Nervensystem“ entschieden, aber es gibt auch andere Plattformen, mit denen interne und externe Unternehmensprozesse gesteuert werden können.

Aber kommen wir zurück zum „elektronischen Gehirn“. IT-Spezialisten arbeiten an Informationsdiensten, die die Effizienz der Flottenverwaltung, die Qualität der Planung und das Niveau des Kundenservice verbessern können. Mithilfe mathematischer Modelle erstellt das System einen Transportplan zur Optimierung von Leerfahrten und Stillstandzeiten der Waggons. Die Algorithmen müssen viele Faktoren berücksichtigen: die Betriebsbedingungen im Eisenbahnnetz, die Dislokation der Waggons, den Mangel und Überschuss im Fuhrpark, Reparaturtermine und vieles mehr. Es ist wichtig, dass das Modell lernfähig ist, da es unmöglich ist, alle Faktoren in der Produktentwicklungsphase zu berücksichtigen. Das kontinuierliche Training des Modells ist der Schlüssel zum Erfolg des Algorithmus in Entscheidungsunterstützungssystemen.

Neben der Planung des Wagenverkehrs können Informationssysteme auch die Berechnung der Transportkosten beschleunigen. Früher mussten Kunden mehrere Tage auf kommerzielle Angebote warten, heute dauert die Berechnung nur noch wenige Stunden. Bei der automatischen Berechnung werden zahlreiche Parameter berücksichtigt, darunter die Prognose für Leerfahrten und Ausfallzeiten bei Start- und Endvorgängen. Auf der Grundlage dieser Parameter wird der endgültige Preis für eine bestimmte Anfrage ermittelt.

IT-Plattformen beschleunigen die Zusammenarbeit mit Wagenreparaturunternehmen. Beispielsweise nutzen wir bei der Zusammenarbeit elektronische Dokumentenverwaltung und digitale Signaturen. Durch die Integration unserer Informationssysteme werden die erforderlichen Reparaturinformationen automatisch zwischen den Unternehmen ausgetauscht, ohne dass manuelle Anfragen erforderlich sind. Betreiber und Wagenreparaturunternehmen verwalten die Reparatur von Wagen in Echtzeit. Solche Veränderungen beschleunigen die Prozesse erheblich, was bedeutet, dass die Kunden ihre Transportmittel schneller und in besserer Qualität erhalten.

Informationstechnologien werden nicht nur von den Betreibern, sondern auch vom Transportunternehmen aktiv genutzt – also von dem Unternehmen, das die Eisenbahninfrastruktur des Landes besitzt und den Personen- und Güterverkehr sicherstellt. Mithilfe von IT-Systemen werden die Strecken und Fahrpläne der Züge im Netz ausgearbeitet, die Intervalle für Weichen und Signalanlagen festgelegt und notwendige Änderungen umgehend vorgenommen. So hat beispielsweise das japanische Unternehmen Toshiba dem Markt ein System zur Steuerung des Schienenverkehrs angeboten, das aus mehreren Systemen besteht: Zugverkehrskontrolle, Planung und Steuerung der Stromversorgung. Es erhöht die Stabilität und Effizienz des Bahnbetriebs sowie die Flexibilität gegenüber Änderungen im bestehenden Schienennetz. Ähnliche Lösungen werden in verschiedenen Ländern der Welt entwickelt und eingeführt.

Darüber hinaus rückt die Eisenbahn näher an ihre Kunden heran. So werden beispielsweise für die Zusammenarbeit mit Partnern heute moderne CRM-Systeme eingesetzt. Einige nutzen fertige Lösungen, andere entwickeln ihre eigenen. So schafft der russische Transportdienstleister ein eigenes System für die Zusammenarbeit mit Versendern. Es enthält Informationen zu rund 300 verschiedenen Produkten und Dienstleistungen des Unternehmens und seiner Tochtergesellschaften. Ein Großteil der Dienstleistungen des elektronischen Katalogs ist auf die Optimierung der Nutzung von Güterwagen ausgerichtet: die Organisation von Güter-Expresszügen – Schnellzügen, die Routenplanung für den Wagenverkehr und vieles mehr.

Eine weitere Lösung, die die Arbeit von Kunden und Eisenbahnbetreibern vereinfacht hat, ist eine Online-Plattform für die Bestellung von Transporten, Waggons und damit verbundenen

Dienstleistungen. Die Bestellung einer Dienstleistung dauert nur wenige Minuten. Die größten Unternehmen haben dort bereits ihre Waggons platziert, und die Plattform wird ständig erweitert. Die Plattform eignet sich besonders für Frachtbesitzer, deren Transporte über das Netz unregelmäßig oder „dringend" sind.

Darüber hinaus wurde die Entwicklung von Quantenkommunikationstechnologien auf dem Markt gestartet. Quantentechnologien beziehen sich auf die sichere Übertragung von Nachrichten und Informationen über große Entfernungen. Bislang wurde ein solches System nur in China implementiert.

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VERBESSERUNG DER EFFIZIENZ DES EISENBAHNVERKEHRS

Die ukrainische Eisenbahn, die noch vor 10 bis 15 Jahren zu den innovativsten im postsowjetischen Raum gehörte, liegt heute deutlich hinter ihren Nachbarn zurück. Welche neuen Technologien wurden im Güterverkehr nicht eingeführt, und welchen Beitrag hätten sie zur Effizienz des Unternehmens leisten können?

Die weltweite Erfahrung zeigt, dass eine effektive Entwicklung des Schienenverkehrs ohne die Einführung von Innovationen nicht möglich ist.

In der Regel gehen diese in folgende Richtungen: Verbesserung der technischen Eigenschaften des rollenden Materials und der Gleise, Containerisierung von Gütern, Elektrifizierung und Nutzung neuer Energiequellen, Computertechnologien.

Einer der wesentlichen Faktoren für die Verbesserung der Effizienz ist die Erhöhung der Tragfähigkeit von Waggons. Die Argumente hierfür sind einfach und verständlich: Je mehr jeder Waggon transportiert, desto geringer sind die Transportkosten.

Die Tragfähigkeit hängt wiederum von der maximal zulässigen Achslast ab. Viele Länder mit einem gut ausgebauten Eisenbahnnetz setzen seit langem erfolgreich auf den Schwerlastverkehr.

Auf einzelnen Streckenabschnitten in den USA, Kanada, Mexiko, Australien und Südafrika liegt dieser Wert sogar bei über 40 Tonnen.

In einer Reihe von Staaten mit einer Spurweite, die derjenigen in der Ukraine entspricht (1520 mm), wurde heute ebenfalls eine Standard-Achslast von 25 t eingeführt.

Unser Land ist eines der wenigen, in denen 23,5 Tonnen vorgeschrieben sind. Der Unterschied scheint gering zu sein. Die Erfahrung mit dem Einsatz innovativer Waggons mit einer Achslast von 25 Tonnen zeigt jedoch, dass ihre Produktivität um 7 bis 10 % höher ist.

In der Ukraine wurde ein Halbwagen mit einer Ladekapazität von 25 Tonnen bereits 2007 von der Aktiengesellschaft „Kryukovsky Wagon Building Plant" (KVSZ) hergestellt. Diese Fahrzeugserie blieb jedoch ein Prototyp. Eine Serienproduktion kam nicht zustande.

Etwas später, im Jahr 2012, stellte das heimische Werk auch einen Getreidewagen mit erhöhter Achslast her. Ähnliche Fahrzeuge wurden auch von anderen ukrainischen Wagenbauunternehmen, insbesondere von der AG „Azovmash", in Produktion genommen.

Es wird davon ausgegangen, dass eine Erhöhung der Belastung von 23,5 auf 25 t/m im Rahmen der Infrastruktur des „sowjetischen" Standards durchaus möglich ist. Allerdings ist derzeit der schlechte Zustand der Gleise ein Hindernis für den massenhaften Einsatz von Wagen mit erhöhter Achslast in der Ukraine.

Da die Meinungen der Wissenschaftler über die Auswirkungen schwerer Waggons uneinheitlich sind und ein Großteil der Eisenbahninfrastruktur überfällige Reparaturen und Sanierungen benötigt, traut sich niemand, die Verantwortung für die sichere Umsetzung des Projekts zu übernehmen.

So mussten Anfang letzten Jahres 5,9 Tausend Kilometer (also fast ein Viertel) der Gleise einer Generalüberholung unterzogen werden, was eine Folge der seit mehr als 10 Jahren aufgestauten Arbeiten ist.

Zu den Befürwortern einer Erhöhung der Achslast gehört neben den heimischen Waggonbauern auch das amerikanische Unternehmen Amsted Rail. Es verfügt bereits über Erfahrung mit der

Modernisierung von Güterwagen der Ukrzaliznytsia.

Es ist anzumerken, dass innovative Wagen nicht unbedingt Rollmaterial mit einer Achslast von 25 Tonnen sind, sondern auch solche mit „Kassetten"-Kegelrollenlagern, die längere Wartungsintervalle haben. Ihre Einführung wird gerade auf der ukrainischen Eisenbahn recht aktiv vorangetrieben.

In der Ukraine werden solche Komponenten vom „Charkower Lagerwerk" hergestellt, das zur Industriegruppe UPEC von Anatolij Girschfeld gehört.

Wie auf der Website des Unternehmens angegeben, präsentiert HARP heute „eine neue Generation energieeffizienter „Kassetten"-Lagerbaugruppen mit einer erhöhten Lebensdauer zwischen 0,8 Mio. km und 1 Mio. km".

Durch den Einsatz solcher Komponenten sinkt die Anzahl der Wagen, die wegen Defekten am Radsatz zur Reparatur ausgemustert werden müssen, im Vergleich zu Wagen, die mit herkömmlichen Zylinderlagern ausgestattet sind. Dies verbessert die Effizienz des Rollmaterials.

Das Fahrwerk der meisten Güterwagen in der Ukraine ist nichts anderes als eine Kopie der dreiteiligen Drehgestelle, die bereits 1928 von der amerikanischen Firma Barber entwickelt wurden.

In den meisten Ländern der Europäischen Union wird ein völlig anderer Konstruktionstyp verwendet. Diese Drehgestelle sind komplexer, aber leiser, was für die EU besonders wichtig ist. Es gibt auch die Meinung, dass sie besser für den Hochgeschwindigkeitsverkehr geeignet sind und die Gleise weniger belasten.

Eine flächendeckende Umstellung auf europäische Drehgestelle ist in der Ukraine jedoch in naher Zukunft kaum möglich, da die Umrüstung und die Umstellung der Technologie in der Branche enorme Kosten verursachen würden.

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EFFIZIENZ DES GÜTERVERKEHRS

Eine weitere Technologie, mit der die Effizienz des Güterverkehrs gesteigert werden kann, ist der Einsatz von Gelenk- oder Mehrfachachswagen.

Diese Technologie hat sich auf den Eisenbahnen der USA durchgesetzt und wird derzeit in der Russischen Föderation weiterentwickelt.

Gelenkwagen ermöglichen es, bei gleicher Zuglänge und ohne Erhöhung der Achslast mehr Fracht zu transportieren.

Während ein Zug mit Standard-Halbwagen etwa 6,5 bis 6,7 Tausend Tonnen transportieren kann und ein Zug mit 25-Tonnen-Wagen mehr als 7 Tausend Tonnen, kann ein Zug aus Gelenk-Halbwagen fast 9 Tausend Tonnen transportieren.

In der Ukraine gibt es keine Berichte über ähnliche Entwicklungen.Um schwere und lange Züge zu fahren, sind leistungsstärkere Lokomotiven erforderlich. Dabei handelt es sich in erster Linie um Fernverkehrselektrolokomotiven.

Länder mit einem gut ausgebauten Eisenbahnnetz und hoher Frachtintensität wie die USA, Russland und Indien setzen auf leistungsstarke Traktion.

Ende der 2000er Jahre wurde eine Charge von 15 Wechselstrom-Elektrolokomotiven 2ES5K „Ermak" (Hersteller: „Novocherkassk Electrolocomotive Plant") an das Depot Podolsk der Odessa-Eisenbahn geliefert.

Sie sind bis heute in Betrieb. Im Vergleich zu ihren Vorgängern vom Typ VL80 zeichnen sich diese Maschinen durch eine um 7 % höhere Zugkraft aus. Die Leistung der Lokomotiven beträgt 6560 kW.

Ausgehend von den Betriebserfahrungen mit der 2ES5K ermöglicht diese Lokomotive eine Erhöhung des Zuggewichts um durchschnittlich 1000 t.

Eine Möglichkeit, die Leistung von Lokomotiven zu steigern, ist neben der zweiteiligen Ausführung (oder der Kopplung mehrerer Maschinen) die Ergänzung durch einen dritten Booster-Abschnitt.

Die größte Kraft wird bei gleichzeitiger Verwendung von vier Abschnitten erreicht. Leistungsstarke Lokomotiven sind besonders rationell in schwierigem Gelände einzusetzen, wie beispielsweise in den ukrainischen Karpaten oder im Donbass.

Auf einer der größten Eisenbahnstrecken der Welt – in Indien – wurde im Mai dieses Jahres eine zweiteilige Güterzuglokomotive WAG-12B mit einer Leistung von 9000 kW in Betrieb genommen.

Ähnliche Lokomotiven vom Typ KZ8A mit einer Leistung von 8800 kW werden in Kasachstan hergestellt und betrieben. Sie werden gemeinsam mit dem französischen Unternehmen Alstom produziert. Die Lokomotiven sind für den Antrieb von Güterzügen mit einem Gewicht von bis zu 9000 t ausgelegt.

Natürlich muss die Frage der Erhöhung des Zuggewichts komplex gelöst werden, wobei neben der Zugkraft und den Waggons auch der Zustand der Gleise und der Energieanlagen berücksichtigt werden muss, die in der Ukraine ebenfalls stark abgenutzt sind.

Neben der Steigerung des Güterverkehrs umfassen Innovationen auch die Erhöhung der Geschwindigkeiten von Güterzügen.

Eine weit verbreitete Technologie hierfür ist das durchgehend verschweißte Gleis – verschweißte Schienen mit einer Länge von bis zu mehreren Kilometern.

In der Ukraine wird diese Technologie hauptsächlich auf Streckenabschnitten eingesetzt, die von Personenzügen befahren werden. In den Vereinigten Staaten hingegen, wo die Eisenbahnstrecken vorwiegend dem Güterverkehr dienen, ist mehr als die Hälfte der Strecke barrierefrei gestaltet.

Eine weitere vielversprechende Technologie ist der schotterlose Gleisbau (auf einem Stahlbetonunterbau). In Deutschland wird er bereits sowohl im Personen- als auch im Mischverkehr eingesetzt.

Man geht davon aus, dass diese Art von Schiene ihre Geometrie besser beibehält, länger hält und praktisch keine Wartung benötigt.

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ENTWICKLUNG DES EISENBAHNVERKEHRS IN DER UKRAINE

Die Ukraine hinkt im Bereich der Elektrifizierung des Schienennetzes vielen europäischen Ländern deutlich hinterher.

Beispielsweise sind in unserem Land nur 47 % der Gleise oberirdisch, während es in Polen bereits 62 % sind. Zahlreiche europäische Bahnstrecken sind nahezu vollständig elektrifiziert.

Der Elektrifizierungsgrad des ukrainischen Schienennetzes liegt deutlich hinter dem der meisten entwickelten Länder Europas und Asiens zurück.

Die Elektrifizierung ermöglicht eine erhebliche Senkung der Kosten für den teuren Dieselkraftstoff, der von den Fernlokomotiven verbraucht wird. Da die Ukraine Dieselkraftstoff hauptsächlich importiert, ist dieses Problem für sie besonders dringlich.

Nach bedeutenden Fortschritten in diesem Bereich zwischen 1994 und 2012 ist der Prozess jedoch nahezu zum Stillstand gekommen. In den letzten acht Jahren wurden lediglich 14 km der Strecke Potoki–Zolotnishino elektrifiziert. Vor diesem Hintergrund ist die Erfahrung Usbekistans, eines der am weitesten entwickelte Länder im postsowjetischen Raum im Hinblick auf den Schienenverkehr, besonders interessant.

In den vergangenen sieben Jahren wurden laut den usbekischen Eisenbahnen über 1.000 km Bahnstrecken elektrifiziert. Aktuell ist etwa die Hälfte der Strecken (insgesamt 7.400 km) auf elektrischen Betrieb umgestellt. Dadurch konnten die Betriebskosten der Züge deutlich gesenkt werden.

Neben der Umstellung auf elektrische Traktion lassen sich erhebliche Energieeinsparungen durch den Einsatz von batteriebetriebenen oder hybriden Rangierlokomotiven erzielen, darunter auch solche, die mit Brennstoffzellen (Wasserstoff) betrieben werden.

Ähnliche Lokomotiven werden bereits von asiatischen Unternehmen wie dem japanischen Unternehmen Toshiba und dem chinesischen Unternehmen CRRC in Serie produziert und auf dem EU-

Markt angeboten.

Wenn von multimodalen Transporten die Rede ist, denkt man in erster Linie an Container. Der Übergang zu Containern half den amerikanischen Eisenbahnen, im harten Wettbewerb mit dem Straßentransport zu bestehen.

In den entwickelten EU-Ländern machen Container bis zu 30 % des Güterumschlags aus. In der Ukraine ist dieser Anteil mit etwas über 2 % noch gering. Er wächst jedoch stetig.

Die rasante Entwicklung des Containerverkehrs kann natürlich nicht von allein erfolgen. Sie erfordert Investitionen in Umschlagtechnik und spezialisiertes Rollmaterial.

In der Ukraine herrscht derzeit ein akuter Mangel an Containerterminals, und auch der Containerplattformpark der Niederlassung Liski Transport Service Center von Ukrzaliznytsia, einer spezialisierten Abteilung, die für den Containerversand zuständig ist, ist veraltet.

Es werden Spezialstapler benötigt – Reachstacker, elektrische Portalkrane, moderne Plattformwagen sowie Kraftfahrzeuge.

Beispielsweise betreibt Metrans an einem der größten Containerterminals Osteuropas, Prag-Urineves in Tschechien, fünf Portalkrane und neun Reachstacker mit unterschiedlichen Tragfähigkeiten. Subunternehmer stellen eine Flotte von 330 Lkw bereit.

Neben dem Containerversand ist auch der Containerversand – der Transport beladener Lkw oder Sattelauflieger auf speziellen Plattformen – von Interesse.

Die Ukraine war Ende der 1990er-Jahre das erste Land im postsowjetischen Raum, das diese Technologie einführte. Sie konnte sich jedoch nie flächendeckend durchsetzen.

Der Vorteil des Containertransports liegt nicht nur in der Liefergeschwindigkeit (nach europäischen Standards müssen mindestens 1.000 km pro Tag zurückgelegt werden), sondern auch darin, dass die Lkw weder Straßen beschädigen noch die Luft verschmutzen. Schließlich ist die Bahn ein umweltfreundlicheres Transportmittel.

Die Technologie der französischen LOHR-Gruppe kann als europäisches Beispiel für die erfolgreiche Umsetzung solcher Transportlösungen angeführt werden.

Das Unternehmen gibt an, in den vergangenen 15 Jahren über eine Million Lkw erfolgreich vom Straßen- auf den Schienentransport umgestellt zu haben.

Der rasante globale Wandel erfordert Veränderungen selbst in einem so konservativen Sektor wie dem Schienenverkehr. Die Industrieländer haben bereits umfangreiche Erfahrungen mit der Umsetzung verschiedener Innovationen gesammelt.

Dies zeigt, dass ohne technische und technologische Innovationen signifikante Effizienzsteigerungen in der Branche unmöglich sind. Gleichzeitig sind viele bewährte Innovationen den ukrainischen Eisenbahnern wohlbekannt und wurden in der Vergangenheit sogar schon in unserem Land eingesetzt.

Experten werden entscheiden, inwieweit diese Faktoren bei der unausweichlichen Erneuerung des Rollmaterials und der Infrastruktur berücksichtigt werden sollen.

Dies wird die zukünftige Entwicklung der ukrainischen Eisenbahnen, der damit verbundenen Branchen und der gesamten Wirtschaft bestimmen.

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MODERNE LÖSUNGEN FÜR DIE INSTANDHALTUNG VON EISENBAHNEN

Zustandsorientierte Überwachung und Instandhaltung sind unerlässlich für die Sicherheit, Wirtschaftlichkeit und den reibungslosen und effizienten Betrieb von Eisenbahnanlagen. Regelmäßige Inspektionen und Wartungsarbeiten sind notwendig, um Mängel zu vermeiden, die zu Fahrzeug- oder Infrastrukturschäden führen können. Hochpräzise Zugmesssysteme und bordseitige Überwachungssysteme, die Zug-, Gleis-, Oberleitungs- und Stromabnehmerparameter erfassen, liefern entscheidende Daten und Erkenntnisse für moderne Instandhaltungslösungen. Die physikalische Welt der HBK-Sensoren, -Tests und -Messungen ist mit der digitalen Welt der Modellierung, Software und

Analyse verknüpft.

Verlässliche Daten sind unerlässlich, um die technischen und wirtschaftlichen Vorteile der verfügbaren Daten zu verstehen. Dies schützt Investitionen, Betriebsabläufe und die Sicherheit. Daher sind zuverlässige Messungen von grundlegender Bedeutung.

Bisher wurden Diagnose- und Überwachungsdaten typischerweise nur in Form von Ausfallberichten oder ungenauen Messdaten bereitgestellt. Solche Daten weisen häufig erhebliche Schwankungen auf und eignen sich nicht für zuverlässige Prognosen. Daher müssen Züge und Infrastruktur mit spezieller Messtechnik ausgestattet werden.

Um das Risiko potenzieller Schäden am Schienennetz zu reduzieren und Zeit, Ressourcen und Geld zu sparen, bietet HBK eine komplette Lösungssuite für die Messung und Überwachung von Schienenfahrzeugen und Infrastruktur mit TSI-SPOT sowie Sensoren und anderen Komponenten, die es den Kunden ermöglichen, ihre eigenen Lösungen zu entwickeln.

Hochwertige Daten sind die Grundlage für eine effektive Instandhaltungsplanung. Die modernen, hochpräzisen Messsysteme von HBK ermöglichen neue, zukunftsorientierte Ansätze für Instandhaltung und Reparatur – von der routinemäßigen Wartung über die vorbeugende Instandhaltung bis hin zu Lösungen für die planmäßige Instandhaltung von Gleisen, Oberleitungen und Schienenfahrzeugen.

Der Begriff TSI-SPOT bezeichnet das Angebot von HBK für die Bahnindustrie und umfasst ein Ökosystem aus optischen und elektrischen Sensoren, Datenerfassungssystemen – QuantumX und SomatXR – sowie Softwarelösungen für Datenanalyse und -modellierung und Verbindungen zu kommerziellen Daten.

Der TSI-SPOT-Ansatz (Technische Spezifikationen für Interoperabilität) in Form von zusätzlichen und bordseitigen Messungen gewährleistet eine innovative Instandhaltung des Schienenfahrzeugbestands und der Infrastruktur sowie den reibungslosen Betrieb des gesamten Systems.

HBK bietet ein breites Spektrum an Messlösungen für gleisige Zugmess- und Überwachungssysteme:
Radfehlererkennung
Fahrverhaltensmessung
Messung horizontaler, vertikaler und longitudinaler Kräfte sowie des Wagengewichts
Achszählung
Geräusch- und Vibrationsmessung.

Die steigenden Effizienzanforderungen in der wachsenden Schienenverkehrsbranche erfordern eine prioritäre Gleisinstandhaltung, bevor Schäden am Rollmaterial durch schlechte Bedingungen entstehen. HBK bietet fortschrittliche Technologien, die es der Branche ermöglichen, die Instandhaltungsplanung von Gleisen und Oberleitungen zu optimieren. Die Systemlösungen und Komponenten von HBK bieten vollautomatische, autonome Gleiszustandsüberwachungssysteme – eine Komplettinstallation, das Folgende umfasst:
Informationen zu Beschleunigung, Verformung und Temperatur
Integration des Borddatenbusses
Qualitätsbewertung der Daten und automatische Berichtserstellung
Standortbasierte Netzwerküberwachung
Robuste Lösung mit langfristiger Zuverlässigkeit
Brandgeschützte Elektronik
Identifiziert Problembereiche und bewertet deren Schweregrad, um eine vorausschauende Wartungsplanung zu ermöglichen.

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KÜNSTLICHE INTELLIGENZ IM BAHNMANAGEMENT

Das Kapazitäts- und Verkehrsmanagementsystem (CTMS) ist als Schlüsselelement der Digitalisierungs- und Automatisierungskapazitäten der Deutschen Bahn (DB) konzipiert. Das CTMS

nutzt künstliche Intelligenz und verwendet ein Multi-Agent Reinforcement Learning (MARL)-Verfahren, um detaillierte Fahrpläne deutlich schneller als herkömmliche Optimierungsmethoden zu erstellen.

Das CTMS-System wird im Rahmen der Initiative „Digitale Schiene Deutschland“ (DSD) der Deutschen Bahn entwickelt. Ziel der DSD ist die Verbesserung von Netzkapazität, -qualität und -effizienz durch den Einsatz digitaler Technologien. Die DSD-Initiative wird von einem gleichnamigen Unternehmen umgesetzt, das von der DB-Holdinggesellschaft gegründet wurde. Zu den Aufgaben des CTMS gehören die Automatisierung der Fahrplanerstellung und der Zugdisposition.

Die Erstellung der Fahrpläne für die rund 40.000 Züge, die täglich im DB-Netz verkehren, erfordert derzeit monatelange Vorarbeit von Experten mithilfe spezialisierter Software. Tausende Fahrdienstleiter und Bahnhofsmitarbeiter sorgen für einen reibungslosen Betrieb und beheben Störungen. Jeder Fahrdienstleiter ist für einen bestimmten Bereich zuständig und koordiniert seine Arbeit nicht nur mit anderen Fahrdienstleitern und Bahnhofsmitarbeitern, sondern auch mit den Fahrdienstleitern verschiedener Betreiber. Die Möglichkeiten dieser herkömmlichen Technologie stoßen bei zunehmender Netzauslastung und dem Bedarf an hoher Flexibilität im Betrieb an ihre Grenzen. Ein hochautomatisiertes CTMS-System soll daher eine umfassende Fahrdienstleitung im gesamten Netz gewährleisten.

Das CTMS-System gilt als universelles Werkzeug zur Erstellung von Fahrplänen für den gesamten Planungshorizont des Eisenbahnsystems – von der langfristigen Planung (einschließlich Gleisinstandhaltung) bis hin zur operativen Planung für die Steuerung laufender Transportprozesse. In allen Phasen werden Fahrpläne generiert, die detailliert genug sind, um einen automatisierten oder vollautomatisierten Zugbetrieb und die automatisierte Steuerung von Stellwerken zu unterstützen. Das CTMS unterstützt sowohl traditionelle Intervallsteuerungssysteme auf Basis fester Blockabschnitte als auch die fortschrittliche, zugzentrierte Sicherheitslogik, die im Zielmodell der DSD-Initiative vorgesehen ist.

Für ein komplexes Entscheidungssystem wie CTMS entwickelt DSD eine auf künstlicher Intelligenz basierende Planungstechnologie auf Basis der MARL-Methode. Deren Anwendung soll die für CTMS erforderliche Vielseitigkeit und Skalierbarkeit gewährleisten. Das französische Unternehmen InstaDeep, spezialisiert auf die Implementierung von KI-Tools in verschiedenen Branchen und im Transportwesen, ist an der Entwicklung dieser Technologie beteiligt.

Beim Deep Reinforcement Learning (DRL) werden neuronale Netze trainiert, um komplexe Probleme durch Interaktion mit einem dynamischen Simulationsmodell zu lösen. DRL hat sich in der strategischen Planung und im kontinuierlichen Echtzeit-Prozessmanagement bewährt. Für das CTMS-System entwickelte DSD ein hochpräzises Eisenbahnsimulationsmodell, das alle relevanten Aspekte des Betriebs abbildet. Dazu gehören eine detaillierte Beschreibung des realen Eisenbahnnetzes, die physikalischen Eigenschaften des Rollmaterials, die Sicherheits- und Steuerungssysteme für verschiedene Zugtypen sowie technologische Prozesse wie die Ankunft von Zügen im Bahnhof. Unter diesen Bedingungen ist das Steuerungssystem in der Lage, Zugbewegungen, ohne den Einsatz von KI zu koordinieren und Weichen, zulässige Geschwindigkeiten und Haltezeiten an Bahnhöfen festzulegen.

Im Gegensatz zu klassischen Methoden strebt künstliche Intelligenz (KI) nach einer akzeptablen, aber nicht unbedingt optimalen Lösung. Ihre Stärken liegen in der intelligenten Datenreduktion und dem parallelen Rechnen, was eine schnelle Lösungsfindung ermöglicht. Dies ist entscheidend für ein Echtzeit-Zugleitsystem. Die für CTMS entwickelte Methode basiert auf DRL, ist aber nicht auf die Optimierung bestehender Fahrpläne, sondern auf deren Erstellung von Grund auf ausgelegt und erstellt einen Fahrplan für ein spezifisches Betriebsgebiet. Daher beschränkt sich ihr Anwendungsbereich nicht auf die Zugdisposition, sondern umfasst auch die operative Planung. Die Fokussierung auf die Steuerung jedes einzelnen Zuges unter Berücksichtigung der gesamten Betriebssituation ermöglicht die Parallelisierung von Berechnungen und die Skalierbarkeit auf große Betriebsgebiete mit einer Vielzahl gleichzeitig verkehrender Züge.

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НАУКОВЕ ВИДАННЯ

ТЕЗИ ДОПОВІДЕЙ

Міжнародної наукової мультидисциплінарної конференції студентівта молодих учених *Новітні технології: покращення сьогодення та вплив на майбутнє*

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