

The 26th International Multi-Conference

**RELIABILITY and STATISTICS
in TRANSPORTATION and COMMUNICATION
(RelStat'26)**

15-17 October 2026. Riga, Latvia

Organised by

Transport and Telecommunication Institute (Latvia)
in co-operation with
Latvian Academy of Science (Latvia)

ABSTRACTS

Edited by

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RIGA - 2026

Abstracts of the 26th International Multi-Conference *RELIABILITY and STATISTICS in
TRANSPORTATION and COMMUNICATION* (RelStat'26), 15–17 October 2026, Riga, Latvia.

Transport and Telecommunication Institute
Lauvas street 2, LV-1019, Riga, Latvia
<http://RelStat.tsi.lv>

ISBN

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Sustainable Logistics

TECHNICAL ASSESSMENT METHODS FOR LIGHT UNMANNED AERIAL VEHICLES: A REVIEW FROM CONVENTIONAL AVIATION TO SMALL-SCALE SYSTEMS

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Keywords: Unmanned aerial vehicle, structural health monitoring, vibration diagnostics, wind tunnel testing, aeroelastic response, composite airframe

This review paper presents a comprehensive analysis of technical assessment methods for light unmanned aerial vehicles (UAVs), covering approaches derived from conventional manned aviation as well as solutions tailored to small-scale un-manned platforms. With the rapid expansion of the UAV sector, there is an increasing demand for reliable, scalable, and cost-effective methods to evaluate their technical condition and operational safety. The paper systematizes existing approaches, including classical structural inspection procedures, non-destructive testing (NDT), structural health monitoring (SHM), and methods based on operational data analysis and numerical modeling. Attention is given to differences arising from vehicle scale, structural materials, and operational environments.

The review also highlights key gaps in current methodologies, especially in the context of light UAVs, for which traditional certification procedures are often inadequate or economically impractical. The integration of experimental measurements with numerical models is identified as a promising direction for the development of more effective technical assessment frameworks.

As a case study, an experimental investigation of a damaged light UAV is presented. The structure was instrumented with accelerometers to capture its dynamic response under controlled aerodynamic conditions in a wind tunnel. Tests were conducted across a range of airflow velocities and angles of attack, enabling the identification of changes in dynamic characteristics and potential indicators of structural degradation. The results demonstrate a high sensitivity of acceleration-based measurements to variations in structural stiffness, confirming the potential of this approach for damage detection in UAV systems.

This work provides a foundation for future research on integrated technical assessment methods for light UAVs, combining experimental approaches while addressing the specific challenges of small-scale unmanned platforms.

A STRUCTURED DECISION LOGIC FOR INTEGRATING CARGO BIKES INTO MUNICIPAL VEHICLE FLEETS

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Keywords: Cargo bikes, commercial traffic, fleet management, municipal enterprises

Municipalities face growing pressure to make their vehicle fleets more sustainable, reinforced by the German Clean Vehicles Procurement Act. Cargo bikes are promising, but many municipal organisations are unsure which tasks they can perform and when they are preferable to conventional vehicles.

We aimed to identify typical municipal applications where cargo bikes are operationally feasible and to develop a framework that supports vehicle procurement decisions, even with limited data and resources.

In addition to a comprehensive literature review, we interviewed municipal service representatives to understand how vehicle decisions are made in practice, which data are available, and why cargo bikes are chosen. We found that little or no data are often collected, so decisions are frequently based on experience rather than systematic evidence.

From these findings, we developed a two-step decision-making framework using a concise set of qualitative criteria. It helps identify suitable vehicle types for specific municipal tasks and considers social and environmental aspects alongside economic factors.

A CONFIGURABLE SIMULATION MODEL FOR FLEXIBLE RURAL LAST-MILE POSTAL DELIVERY: A LATVIJAS PASTS CASE STUDY

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Keywords: Synchromodal logistics, last-mile delivery, parcel locker networks, multimodal transportation, simulation-as-a-service, emissions

This research addresses the operational transition from traditional static logistics to dynamic, synchromodal transport networks with the potential to balance cost, delivery time, and environmental performance. Extending the principles of intermodal freight, synchromodality enables the real-time re-routing of loading units to mitigate network disruptions and fulfill changing customer requirements.

This study develops and verifies a configurable simulation model for flexible last-mile postal delivery in rural areas. The model combines discrete-event and agent-based modelling with GIS data to represent alternative delivery schemes involving customer self-collection, scheduled public transport and volunteer carriers. Its application is illustrated using the geographical context of a selected area of Saldus municipality, Latvia. A daily scenario was used to verify the representation of vehicle routes, scheduled stops and coordinated parcel-handover events. The model also supports calculating technical and logistical indicators, including vehicle distances, delivery activities, and customer-attributed CO₂ emissions across different service schemes. The results demonstrate the model's ability to reproduce the specified delivery processes and compare alternative configurations within the adopted scenario assumptions. Because only the geographical data were empirical, the study constitutes model verification rather than external validation of Latvijas Pasts operations. The configurable model may subsequently serve as a component of a Simulation-as-a-Service environment to evaluate rural postal delivery alternatives.

MEETING THE REQUIREMENTS FOR THE DIGITAL PRODUCT PASSPORT – BUT WHICH ONE?

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Keywords: Digital product passport, battery passport, digital twin, supply chain, circular economy

Companies face both challenges and opportunities when it comes to the Digital Product Passport (DPP). At first glance, the DPP appears to be a new regulatory burden, arriving at a time when many European companies hope for less regulation rather than more.

At the same time, the literature paints a different picture: the DPP can promote circularity and enable inter-organizational transparency and traceability of products, materials, and components. This raises an important question: which set of requirements should companies actually follow, the one set by EU law or the one discussed in the literature, and are these two sets of requirements aligned or in conflict?

This work compares the requirements set by the EU with those identified in the DPP literature.

The results show that these requirements largely align, meaning that companies can use a DPP not only to meet regulatory demands but also to enable circularity, transparency, and traceability.

TOWARDS A SUSTAINABLE BALANCED SCORECARD FOR GREEN TRANSITION OF REGIONAL AIRPORTS

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Keywords: Regional airports, decarbonization, green transition, sustainable balanced scorecard

The global aviation sector is currently navigating a dual transformation characterised by digitalisation and the urgent need for decarbonisation. For regional airports in Northern Europe, the transition to electric and hydrogen-powered aviation represents a strategic imperative for ensuring economic resilience and social cohesion. However, existing management practices often lack integrated frameworks to evaluate technological readiness from a multi-dimensional sustainability perspective.

This study proposes an adapted Sustainability Balanced Scorecard (SBSC) framework designed to assess the readiness of regional airport infrastructure for green aviation operations. The research addresses two primary questions. First, the methodological adaptation of the SBSC to capture "readiness" as a strategic capability. Second, the identification of infrastructure and management gaps through a comparative analysis of Estonian regional airports and established Northern European benchmarks.

The methodology is based on case studies that are complemented by expert interviews and secondary data. In a comparative case study analysis four Estonian regional airports (Tartu, Pärnu, Kuressaare, and Kärdla) are benchmarked against high-readiness regional airports in Nordic countries. The framework integrates technical, environmental, and social indicators into a unified decision-support tool, providing preliminary estimations of the capital expenditure (CAPEX) required for critical upgrades, such as megawatt-scale grid connections, specialised battery charging and storage facilities and mobile hydrogen refueling units.

The findings of the research are formulated in a formal roadmap for the Estonian airports in order to bridge the existing gap. Generally, by reframing technological readiness as a strategic asset within the SBSC, this paper provides airport operators and policy-makers with a reliable roadmap for the 2026–2030 investment cycle, contributing to the development of sustainable and resilient transport systems.

TECHNICAL REALISATION OF A SIMULATION-AS-A-SERVICE PLATFORM FOR TRANSPORTATION USING A LAYERED ARCHITECTURE

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Keywords: Simulation-as-a-service, transportation systems, co-simulation, service-oriented architecture, model interoperability, orchestration

Simulation-as-a-Service (SIMaaS) provides a promising approach for integrating heterogeneous simulation models within distributed transportation modelling environments; however, practical methods for transforming existing standalone models into interoperable simulation services remain insufficiently developed. This paper presents an implementation-oriented framework for the technical realisation of SIMaaS in transportation. The proposed approach combines a formal definition of a simulation service, a six-stage Simulation Service Transformation Methodology, a machine-readable Simulation Service Description Model (SSDM), and an orchestration mechanism for coordinated execution of heterogeneous simulation services. The SSDM describes simulation specific characteristics, including modelling paradigm, domain, exchanged data, temporal and synchronization properties, execution requirements, and communication interfaces, enabling service discovery and multidimensional compatibility assessment. A reference implementation demonstrates the approach using microscopic road traffic and logistics terminal simulation services, exposed through standardized REST interfaces and coordinated through conservative fixed-barrier synchronization. Experimental evaluation demonstrates successful SSDM-based compatibility assessment, bidirectional event transfer, entity and temporal consistency, and coordinated execution. Synchronization experiments further demonstrate the computational trade-off associated with coupling frequency: for the evaluated scenario, reducing the synchronization interval from 120 s to 1 s increased total measured runtime from 1.17 s to 76.73 s, while all configurations exchanged the same 77 events with a 100% successful event-transfer rate. The results demonstrate the technical feasibility of the framework and show that heterogeneous simulation models can operate as reusable and interoperable services while preserving their native simulation environments.

INCENTIVES AND REWARDS FOR SUSTAINABLE URBAN LOGISTICS: CHALLENGES, EVIDENCE, AND FUTURE DIRECTIONS

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Keywords: Urban freight, incentive mechanisms, sustainable logistics, stakeholder behaviour

Urban freight keeps cities running, yet it also drives congestion, emissions, curbside conflicts and inefficient use of scarce public space. Infrastructure investment, regulation and vehicle technology have each produced local gains, but none has resolved the fragmented decision-making that spans logistics operators, drivers, retailers, receivers, platform providers, citizens and public authorities. This paper asks how incentive and reward mechanisms can help close that gap. Following a structured narrative review approach, we synthesise peer-reviewed and grey literature on urban freight incentives, organised by incentive type, target behaviour, stakeholder group and evidence strength. The literature is organised into a typology of six incentive families, financial, operational, regulatory or access-based, digital or data-sharing, behavioural or gamified, and reputational, mapped against their relevance across smart loading zones, micro-hubs and cargo-bike logistics, zero-emission delivery, out-of-home delivery and data-sharing platforms. The evidence is strongest for hybrid packages that combine operational benefit with regulatory direction and digital verification, and weakest for schemes built on symbolic rewards disconnected from the operational reality of freight work. Building on this synthesis, we propose a five-component, behaviour-oriented and data-enabled framework, covering behaviour specification, stakeholder alignment, incentive package design, monitoring, and scalability and governance, intended to guide the design and evaluation of incentive-based urban freight policy.

A SIMULATION-BASED APPROACH TO RAILWAY TRESPASS PREVENTION IN SMART TRANSPORTATION NETWORKS: A CASE STUDY IN CROATIA

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Keywords: Trespassing, railway, simulation, prevention, smart transportation networks

Railway trespassing poses a major safety challenge in railway transport, as trespassing accidents often result in fatalities, serious injuries, and material damage, disrupting services and reducing transportation system efficiency. Existing railway infrastructure is not adapted to the needs and natural movement patterns of road participants. In particular, problems stem from the lack of grade-separated crossings, such as underpasses and overpasses, combined with terrain that facilitates rather than discourages trespassing. This paper proposes a simulation-based approach to preventing trespassing in smart transportation networks, including identifying safe routes to primary schools. A representative two-kilometer railway section between Maksimir and Trnava stops in the urban area of Zagreb (Croatia) constitutes a critical zone of railway trespassing. The section is modeled in PTV Vissim to analyze pedestrian–rail interactions and simulate a railway environment. Model input data were collected from primary and secondary sources to identify existing crossing points, trespassing locations, infrastructure, technical, and environmental deficiencies. Multiple infrastructure simulation scenarios are evaluated, including the introduction of pedestrian underpasses and overpasses, as well as deterrent measures. The proposed research develops a simulated solution that enables road users to cross railway tracks while preventing trespassing and maintaining efficient, safe mobility. Furthermore, the study highlights the importance of aligning infrastructure design with actual user behavior to enhance system effectiveness. The findings support the role of simulation as a decision-support tool in a smart transportation network for trespassing prevention and a user-adapted railway environment.



Modelling and Prediction using Machine Learning and AI

RELIABILITY-CONSTRAINED BINARY OPTIMIZATION FOR DYNAMIC DECISION SYSTEMS USING VARIATIONAL QUANTUM ALGORITHMS

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Keywords: Binary optimization, reliability constraint, quadratic unconstrained binary optimization, variational quantum eigensolver, quantum approximate optimization algorithm, route planning, decision systems

Combinatorial optimization decision problems are common in economics, finance, transportation, logistics, and general complex systems, where it is often necessary to select an appropriate option from a finite set of feasible solutions. However, the general approach to such optimization problems typically yields an instantaneous optimal solution that is valid only at the specific time τ_0 at which it is obtained. At a later time τ^* , the underlying conditions may change, and the solution that was optimal at the time τ_0 may no longer satisfy the required constraints. This issue is especially relevant in transportation and system-level planning, where routes, schedules, fleet assignments, network flows, maintenance decisions, and resource allocations must remain feasible under uncertain or changing conditions such as congestion, disruptions, demand fluctuations, infrastructure degradation, or component failures. To address this, the article examines binary optimization problems in which a reliability parameter is introduced as an additional constraint affecting the cost of options within the solution space. Hard reliability constraints ensure that only sufficiently robust solutions are feasible, while soft reliability constraints allow limited violations through penalty terms incorporated into the objective function, making them more suitable for practical applications where trade-offs between optimality, reliability, and cost are unavoidable. The studied constraints are modeled within the framework of emerging quantum optimization methods, such as VQE and QAOA.

AI-SUPPORTED CRISIS AIR TRAFFIC MANAGEMENT: A DYNAMIC CONTINGENCY FRAMEWORK FOR GEORGIAN AIRSPACE

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Keywords: Air traffic management, artificial intelligence, crisis management, human factors

Recent geopolitical crises and sudden airspace restrictions have demonstrated how quickly traffic flows can be redistributed across neighboring Flight Information Regions (FIRs), placing pressure on air navigation service providers. Although ICAO Annex 11 requires air navigation service providers to maintain contingency plans, these are static documents that cannot respond dynamically to evolving crisis conditions. This paper proposes an AI-Supported Dynamic Contingency System (AI-DCS) as a data-responsive complement to static contingency planning and examines how a future integration with Controller-Pilot Data Link Communications (CPDLC), not yet implemented at Tbilisi FIR, could further contribute to safer operational decision-making. Drawing on traffic data, EUROCONTROL network

analysis, Local Single Sky Implementation Plan (LSSIP) Georgia 2024 capacity data and the published AIP Georgia, the paper develops a conceptual framework integrating flight plan data, Mode S radar inputs, FIR entry/exit point loading, sector occupancy indicators and controller duty-time records aligned with ICAO Annex 11 Fatigue Risk Management (FRMS) requirements. As an illustrative scenario, the analysis suggests that AI-enabled early warning based on filed flight plan data could have provided an estimated 20-30 minute lead time before the traffic surge peaked, a hypothesis that warrants validation through simulation and operational data. The analysis also notes that crisis-driven rerouting generated an estimated 1,900 excess tons of CO₂ daily across the network, underscoring the environmental dimension of dynamic flow optimisation. The paper concludes that AI transforms static contingency planning into a living, data-responsive operational tool enhancing resilience, efficiency and human-factor awareness in crisis-responsive air traffic management.

SHAP STABILITY INDEX: MEASURING EXPLANATION STABILITY AS A MODEL-SELECTION CRITERION IN FRAUD DETECTION

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Keywords: Fraud detection, explainable AI, SHAP, model validation, operational risk

Black-box ensemble models achieve strong discriminatory power in fraud detection, an operational-risk task under the Basel II external-fraud category, and their decisions are increasingly explained with post-hoc methods such as SHAP for governance and audit. In our earlier systematic review we identified explainability as a dimension of model robustness that currently lacks quantitative metrics, and noted that post-hoc explanations are sensitive to input noise.

This paper addresses that gap by introducing the SHAP Stability Index (SHAP-SI), a scalar metric that quantifies how much a model's SHAP explanations change under controlled Gaussian input perturbation, and by proposing explanation stability as an additional robustness dimension in model selection. Evaluating three tree-based ensembles, Random Forest, XGBoost, and LightGBM, we find that models with comparable discriminatory power degrade in explanation stability at sharply different rates, and that ranking models by predictive performance differs from ranking them by explanation stability. We propose a two-gate selection procedure and a periodic monitoring loop that incorporate SHAP-SI alongside Basel discriminatory-power metrics.

DIFFERENTIAL GRAPH TRANSFORMER FOR TRAFFIC FORECASTING: A NEW APPROACH TO SPATIO-TEMPORAL PREDICTION ON ROAD NETWORKS

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Keywords: Graph neural networks, differential attention, transformer, intelligent transportation systems

In this paper, we propose to transfer the recently introduced Differential Graph Transformer (DGT), originally developed for stock market forecasting, to the domain of traffic flow prediction. DGT learns to

adjust a predefined graph prior through a differential attention mechanism. Unlike standard attention, which may distribute weight over irrelevant context, differential attention computes the difference between two separate softmax maps, with the aim of suppressing shared attention noise and emphasising the most informative spatial and temporal dependencies. In the present implementation, a sparse index-based proximity graph is incorporated into the first attention map, while a learned subtractive component can modify the effective spatial weighting during prediction.

We evaluate DGT using real-world highway data from the PeMS04 benchmark, comparing its performance against strong baselines including STGCN, ASTGCN and GWNEN, using standard metrics MAE, RMSE and MAPE. We hypothesise that DGT will achieve superior predictive accuracy, particularly under non-recurrent congestion, and provide a novel, data-driven perspective on adaptive graph learning for intelligent transportation systems. This work demonstrates a successful cross-domain transfer of a state-of-the-art graph transformer architecture from financial modelling to transportation engineering.

OPTIMAL SHARED BIKE REBALANCING UNDER UNCERTAIN DEMAND: DOUBLE-THRESHOLD POLICY

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Keywords: Bike-sharing, relocation optimization, double-threshold policy

Empty container repositioning (ECR) and bicycle rebalancing in station-based bike-sharing systems (BSS) are, at their core, the same operations research problems: a network of nodes with stochastic, imbalanced flows of a reusable unit, requiring periodic redistribution under capacity, cost and service level constraints. This paper adopts a stochastic, multi-period inventory-repositioning simulation originally formulated for empty container allocation between depots and ports into a daily rebalancing simulation for a bicycle-sharing network, using public Divvy (Chicago) station and trip data. Several domain specific adjustments made including represent thresholds as fraction of station capacity, replacing ECR leasing mechanism with a lost-sales cost structure, solving the daily repositioning decisions as a capacitated vehicle routing problem over heuristic repositioning rules. The inventory thresholds are optimized using a Simulated Annealing algorithm. The results show that optimizing the thresholds from the initial values of 30% and 80% of station capacity to approximately 39.9% and 85.4%, respectively, reduces the average system cost from 58.37 to 32.03 cost units, corresponding to a reduction of approximately 45.1%. The proposed simulation framework provides a basis for evaluating rebalancing fleet size, inventory threshold policy and sensitivity to cost parameters. It demonstrates the potential for adapting classical inventory-repositioning models from freight logistics to shared-mobility applications.

AGENTIC AI SKILLS FOR RESILIENT SUPPLY CHAINS

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Keywords: LLM agents, supply chain management, LLM tools, cognitive task templates, model context protocol

Large Language Model agents are increasingly considered for supply chain and transportation decision support, yet many operational decisions require calculations, feasibility checks, and traceable

assumptions that free-form model reasoning cannot safely provide on its own. This paper addresses that reliability gap by separating scenario interpretation from auditable execution. It proposes an evidence-backed framework in which supply chain knowledge from text-books, professional standards, and operations-research task templates is represented as Cognitive Task Templates and transformed into validated agentic skills and deterministic LLM tools. The method records domain intent, variables, constraints, suggested tools, and provenance, then generates Python-based tools with typed input/output schemas and validation checks. In a curated experiment pack-age, the Skill Factory produced 226 generated skills, of which 220 were accepted and 6 required revisions, yielding an acceptance rate of 0.97. The agent-facing surface was further curated to 35 accepted deterministic tools across eight professional domains. These results support a bounded academic claim: deterministic tool-generation and tool-surface governance can provide an inspectable substrate for LLM-based supply chain decision support.

PROMPT LANGUAGE EFFECTS ON CODE GENERATION: FUNCTIONAL CORRECTNESS AND COST EFFICIENCY UNDER HUMANEVAL+

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Keywords: Large language models, code generation, multilingual, prompting, functional correctness, generation cost

Large language models (LLMs) are increasingly used for code generation in multilingual development contexts, yet benchmarks still predominantly evaluate English prompts. Many HumanEval-derived multilingual evaluations rely on sparse original test suites that can overstate correctness, and broader multilingual suites rarely report generation cost.

This paper investigates whether prompt language affects functional correctness and generation cost under the stricter HumanEval+ test suite. The evaluation covers eight current LLMs on a fixed subset of 60 HumanEval+ Python tasks stratified by difficulty, across seven prompt languages: English, German, Latvian, Chinese, Hebrew, Cebuano, and Korean, spanning Joshi resource classes 3 to 5. Non-English prompts are translated from English and reviewed by native speakers with a programming background, while code-related prompt elements remain unchanged.

In total, 3,360 zero-shot generations are analysed using Pass@1 and median cost per generation (CPG) relative to the English baseline. Prompt language is not observed as a general functional correctness factor in this setting. Pass@1 varies more by model than by language, with only GLM-5 Turbo on Latvian showing a significant decrease. Generation cost is more language-sensitive and model-specific. GPT-5.4 and Claude Opus 4.6 show consistent median CPG increases for non-English prompts, while Grok 4.20 shows significant but directionally mixed cost shifts. The remaining models show no consistent cross-language cost shifts. Overall, multilingual prompting under HumanEval+ does not necessarily reduce correctness for resource classes 3 to 5, but prompt language should be tracked as a model-specific cost factor.

NEURAL NETWORK-BASED PATH AND TRAJECTORY PLANNING FOR AUTONOMOUS VEHICLES IN CARLA

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Keywords: Optimal control, path optimization, reinforcement, learning, supervised learning, trajectory planning, predicting

Autonomous racing combines strict vehicle-dynamics constraints with incomplete environment knowledge during the first lap. This paper presents a hybrid planning architecture for autonomous path and trajectory planning in a digital twin based on the 3D CARLA simulation software. The considered scenario follows the Formula Student Driverless Trackdrive discipline, where the track is unknown in advance and has to be reconstructed by using the position of construction cones that define the track boundaries.

The proposed approach decomposes the problem into two planning phases. During the first lap, a local planner based on a reinforcement learning trained Soft Actor-Critic generates feasible driving commands using only immediate local track information while simultaneously collecting data for track reconstruction. From the second lap onward, a global planner processes the reconstructed track and predicts an Optimal Control trajectory with a neural network. This prediction is then used as a warm start for an Optimal Control Problem (OCP) solver that refines the trajectory under vehicle-dynamics and track boundary constraints.

The evaluation in CARLA shows that the local planner based on the soft actor critic is capable to safely maneuver the vehicle through the first lap on unseen tracks. The learned global planner model provides physically plausible initialization for the solver. In a warm-start analysis, the hybrid approach reduces the average optimization time compared to a high-iteration OCP reference from 298.79 s to 11.43 s while delivering lower constraint violations than a cold-start solver with the same low iteration budget. These results indicate that combining reinforcement learning, supervised learning, and optimal control is a promising strategy for robust and computationally efficient autonomous trajectory planning in constrained racing scenarios.

SYNTHETIC DATA FOR ANTI-MONEY LAUNDERING TRANSACTION MONITORING AND MODEL EVALUATION

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Keywords: Synthetic data, anti-money laundering, transaction monitoring, suspicious transaction scenarios, class imbalance, model evaluation

The development of anti-money laundering analytics is limited by restricted access to real transaction data. Confidentiality requirements, regulatory restrictions, and the rarity of suspicious events make experiments difficult to re-produce and complicate the comparison of model results. To address this issue, this study proposes a rule-based framework for generating synthetic transaction data for anti-money laundering transaction monitoring and model evaluation. The framework is based on a taxonomy of 34 suspicious transaction scenarios and produces transaction flows that include both regular and suspicious behaviour. Suspicious transactions account for up to 1% of the generated data, which pre-serves a realistic class imbalance. To reflect the evolving nature of money-laundering patterns, two synthetic datasets were created and divided into five sequential data packages with different scenario compositions.

The generated data were used in an analytical workflow that included feature engineering for structured transaction attributes and text descriptions, TF-IDF vectorisation, and class imbalance treatment with SMOTE, ADASYN, and ROSE. Model evaluation focused on expert-selected tree-based methods and included Gradient Boosting, XGBoost, and Random Forest classifiers. The results show that rule-based synthetic transaction data can provide a practical basis for anti-money laundering experiments without the use of sensitive customer information. The framework supports the analysis of rare suspicious events, changing scenario composition, and model behaviour under varying conditions. It can also support further research on synthetic data generation for financial crime analytics and transaction monitoring.

THE IMPORTANCE OF AI AND ML WITHIN AVIATION INDUSTRY

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Keywords: Artificial intelligence, machine learning, optimization, aviation industry, sustainability

The increasing complexity of aviation operations, combined with the growing demand for safety, efficiency, sustainability, and cost optimization, has accelerated the adoption of Artificial Intelligence (AI) and Machine Learning (ML) technologies within the aviation industry. In this study, the importance of AI and ML applications across multiple aviation domains is examined, with particular emphasis placed on operational efficiency, predictive maintenance, air traffic management, passenger experience, and decision-making processes. It is demonstrated that data-driven approaches are increasingly being integrated into modern aviation systems to enhance reliability and reduce operational disruptions for both business and regular aviation.

The role of AI and ML in predictive maintenance is highlighted through the analysis of real-time aircraft performance data, where potential failures can be identified before critical failures occur. The approach helps to reduce aircraft downtime, minimize the maintenance costs and helps to improve safety performance. AI-based optimization models are shown to contribute significantly to flight scheduling, fuel consumption reduction, route optimization, and airport resource allocation. In air traffic management, enhanced situational awareness and improved forecasting capabilities are enabled through advanced analytical algorithms.

The influence of AI-driven technologies on passenger services is discussed, including automated customer support systems, biometric identification, personalized travel services, and smart airport operations. Challenges associated with cybersecurity, data privacy, regulatory compliance, and ethical considerations are also acknowledged, as these factors continue to affect the large-scale implementation of intelligent systems in aviation.

It is concluded that AI and ML technologies are becoming essential components of the modern aviation ecosystem. Their integration is expected to transform aviation operations by increasing efficiency, improving safety standards, supporting sustainability objectives, and enabling more intelligent and data-oriented decision-making processes across the industry.

HYPERSPPECTRAL IMAGE RECONSTRUCTION FROM RGB DATA: PROBLEMS AND SOLUTIONS

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Keywords: Hyperspectral imaging, RGB-to-spectrum reconstruction, deep spectral, vision, ill-posed problem, augmented spectral channels

Hyperspectral image (HSI) reconstruction from standard three-channel RGB camera data is a relevant problem in digital signal processing and computing.

The spectral structure of an image carries information about the physicochemical properties of objects; however, much of this information is lost during RGB acquisition because only three measurement channels are available. Recovering the spectrum of each pixel and the complete hyperspectral cube $H(x, y, \lambda)$ from these three channels is therefore an ill-posed inverse problem.

Main classes of spectral reconstruction methods: prior-based, data-driven, and hybrid methods, together with hardware-algorithm co-design are compared in terms of accuracy, computational complexity, data requirements, and hardware implementation constraints. Reconstruction quality metrics are systematized, and publications from 2024-2025 are classified by application area and technological approach.

As an alternative research direction, a recursive mechanism for constructing virtual spectral channels is proposed. Three physical RGB measurement channels are supplemented with N virtual channels whose spectral sensitivity functions are generated analytically by spline interpolation. The resulting three-dimensional surface is then partitioned into spectral ranges, and the estimated responses are refined using physics-informed neural networks. The approach is aimed at reducing the linear dependence between channels and at increasing the accuracy of reconstruction of the HSI spectral components.

STRUCTURED GAME-THEORETIC EXPLANATIONS IN MACHINE LEARNING FOR ROAD COLLISION SEVERITY PREDICTION

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Keywords: Road safety, collision severity prediction, STATS19, explainable AI, SHAP, cooperative game theory, Myerson value, Owen value

Machine learning models for road-safety decision support are typically evaluated by predictive performance, whereas explanation reliability is equally important in safety-critical applications. This paper investigates the stability of feature-attribution methods for binary road collision severity prediction using the UK STATS19 2024 dataset.

A LightGBM classifier is combined with SHAP and several scalable game-theoretic attribution methods, including graph-based Myerson and Owen-style approaches. Explanation robustness is evaluated across stratified cross-validation folds using multiple complementary stability metrics and a composite stability Index. The results show that graph- and coalition-aware game-theoretic attribution methods produce substantially more stable explanations than standard SHAP while preserving meaningful feature

interpretation. The proposed evaluation framework provides a quantitative methodology for assessing explanation robustness in explainable machine learning for road-safety prediction.

DIJKSTRA NAVIGATES GERMANY: A TANGIBLE MULTI-NODE ROUTING ARTIFACT FOR TRANSPORTATION AND DATA SCIENCE EDUCATION

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Keywords: Cyberphysical artefacts in data science education, hybrid learning, Dijkstra Navigates Germany (DNG), tangible user interfaces

Recent educational discourse in data science has been strongly shaped by artificial intelligence, while physical artifacts have received comparatively little attention. This is remarkable, as such artifacts may help make abstract concepts more accessible, particularly prescriptive methods in operations research that students often perceive as difficult to understand.

Dijkstra's algorithm is a foundational shortest-path method in graph theory with important applications in transportation and routing. Although widely used in everyday digital systems, students often struggle to connect its formal logic to practical use.

This paper presents Dijkstra Navigates Germany (DNG), a tangible learning artifact based on the Ravensburger Deutschlandreise board game that visualizes shortest paths, measured in hops, between arbitrary pairs of cities. To support this functionality, 205 nodes were equipped with individually controlled RGB LEDs using custom circuit boards and a Raspberry Pi 400. The software is implemented in Python and uses `scipy.sparse.csgraph.dijkstra` to compute shortest paths. A rigid aluminum-profile case with folding legs enables transport and classroom use.

Following Kirkpatrick's (2006) evaluation framework, DNG was assessed in an exploratory study with students from different academic backgrounds.

Reactions, perceived learning outcomes, behavioral impact, and transfer potential were documented. The evaluation also identified possible functional extensions, such as blocked nodes and edges, as well as broader teaching and learning applications.

ESTIMATION OF THE RADAR CROSS SECTION OF TYPICAL OBJECTS IN LOGISTICS ENVIRONMENTS USING THE 60 GHZ RADAR AND THEIR IDENTIFICATION BY NEURAL NETWORK METHODS

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Keywords: mmwave radar, FMCW radar, radar cross section, object identification, neural networks, mobile robotic platforms

Mobile robotic platforms operating in indoor logistics environments need to identify the static objects around them, and a mmWave radar is attractive for this task because it is immune to dust, smoke and poor lighting. This work examines whether the radar cross section (RCS) of such objects, measured at 60 GHz by an FMCW radar carried by a mobile platform, is sufficient for their identification. The receiving tract was calibrated against reference metal spheres, which yielded the tract constant and confirmed that the response power follows the point-target range law. The mounting height of the radar above the floor was determined experimentally from the fluctuation of the response amplitude. Absolute RCS estimates were then obtained for five classes of typical objects: a round metal column, a chipboard panel, a glass sheet, a rectangular gypsum column and a concrete wall. The measured distributions of the five classes overlap substantially, so a scalar cross section cannot serve as the sole feature for identification. Identification was therefore built on the range profile as a whole. Five neural architectures were trained on the same recordings under cross-validation grouped by recording: a multilayer perceptron on a feature vector, its spiking variant, a one-dimensional convolutional network on a single profile, and a two-dimensional convolutional network, a recurrent network and a self-attention model on windows of consecutive profiles. The recurrent model on frame windows proved the most accurate, and the comparison shows that accuracy is governed by the completeness of the input representation rather than by the architecture.

FROM SHARED INTELLIGENCE TO COLLECTIVE ACTION: A REFERENCE MODEL FOR COLLECTIVE CYBER DEFENCE IN EUROPEAN CRITICAL INFRASTRUCTURE

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Keywords: Collective cyber defence, cyber threat intelligence sharing, critical infrastructure resilience, EU cybersecurity governance

European critical infrastructure increasingly depends on interconnected digital systems, making cyber resilience a collective rather than purely organisational challenge. Cyber Threat Intelligence (CTI) is widely used to anticipate and respond to cyber threats, but its operational value often breaks down when shared information must be translated into coordinated cross-actor action. Existing frameworks such as the NIST CSF and MITRE ATT&CK support individual organisations but do not specify how multiple defenders should institutionally organize collective defence. This paper proposes the Collective Cyber Defence (CCD) model, a two-level reference model for analysing and designing collective defence capabilities in European critical infrastructure. The structural level identifies Integration, Cooperation and Coordination as institutional preconditions; the process level defines a six-link operational cycle from Shared Intelligence and Threat Detection to Coordinated Response, Active Disruption, Ecosystem Recovery and Adaptive Learning.

The model is derived from collective action theory, resilience engineering and operational cyber defence literature, and is applied through a targeted analysis of CTI operationalisation barriers and two EU instruments: the NIS-2 Directive and the Cyber Solidarity Act. The analysis shows that documented barriers concentrate mainly on Shared Intelligence and on institutional problems of trust, reciprocity, interoperability and regulatory fragmentation. Later links, especially Coordinated Response, Active Disruption and Ecosystem Recovery, remain weakly addressed in both the literature and EU regulation. The CCD model therefore reframes collective cyber defence as an institutional design problem for resilient, digitally dependent infrastructures.

A COMPARATIVE STUDY OF INTEGER LINEAR PROGRAMMING FORMULATIONS FOR THE TRAVELING SALESMAN PROBLEM IN PYTHON: PERFORMANCE AND MEMORY USAGE

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Keywords: Dantzig Fulkerson Johnson, integer linear programming, Miller Tucker Zemlin, traveling salesman problem, operations research

This paper investigates the Traveling Salesman Problem (TSP) using two classical integer linear programming formulations. In particular, the formulations proposed by Dantzig, Fulkerson, and Johnson (DFJ) and by Miller, Tucker, and Zemlin (MTZ) are implemented within a unified computational framework and systematically analyzed. The objective of this study is to compare the computational performance of both approaches under consistent experimental conditions.

Performance is evaluated with respect to solution time and memory consumption across varying problem sizes. The analysis aims to provide insights into how the choice of formulation influences computational behavior and resource requirements. By examining both performance metrics under identical conditions, the study enables a direct and consistent comparison of the two approaches.

RELIABILITY ASSESSMENT OF UAV MISSIONS IN INTELLIGENT TRANSPORT ENVIRONMENTS USING STATISTICAL CLUSTERING

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Keywords: Unmanned aerial vehicles, mission reliability, intelligent transport systems, statistical clustering, experimental analysis

The integration of unmanned aerial vehicles (UAVs) into intelligent transport environments raises critical challenges for mission reliability under dynamic operational conditions. This study proposes a data-driven methodology for assessing UAV mission reliability as a multidimensional construct encompassing communication quality, flight stability, navigation accuracy, energy behaviour, and safety response. Using an experimental dataset of 120 missions, unsupervised K-means clustering was applied to identify latent reliability states. The analysis revealed three statistically distinct mission profiles corresponding to high-reliability, moderate-performance, and critical-risk conditions. Cluster separation was strong across all variables, with large effect sizes (η^2 up to 0.897), particularly for packet loss, telemetry latency, and failsafe activations. External validation demonstrated significant differences in Mission Success Score between clusters ($\eta^2 = 0.931$), while cluster membership showed perfect correspondence with predefined reliability classes. These findings confirm that clustered mission profiles provide robust and interpretable representations of UAV operational reliability, supporting quantitative assessment, comparative analysis, and reliability-oriented decision-making in intelligent transport systems.



Wise Transport Systems under Digital Transformation

ANALYSIS OF THE REINTEGRATION OF THE SUBURBAN TRAIN INTO THE MOBILITY SYSTEM OF THE CONSTANTINE METROPOLITAN AREA USING SWOT APPROACH

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Keywords: Suburban train, Constantine, mobility, SWOT

This paper proposes an analytical framework for assessing the opportunity of reintegrating a suburban train into an urban mobility system using the SWOT method. This approach aims to identify the internal and external factors that explain the current underperformance of the service. In this context, the objective of this paper is to offer a diagnostic tool adapted to the context of Constantine, where a functional but largely underused rail service coexists with persistent road congestion. The proposed approach is applied to a real case study: the Constantine suburban train, which currently records a very low ridership. A series of qualitative and descriptive indicators are derived from the four dimensions of SWOT (strengths, weaknesses, opportunities, threats), based on operational data and field observations. This approach thus allows for a better understanding of the barriers to ridership and supports more effective decisions for reintegrating the train into the local mobility system in order to achieve the over-all objectives of sustainable urban mobility.

COMPARATIVE ASSESSMENT OF NUCLEAR, SOLAR AND PROSPECTIVE FUSION POWER SUPPLY FOR HYPERLOOP TRANSPORTATION SYSTEMS USING A SYSTEM DYNAMICS APPROACH

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Keywords: Hyperloop, sustainable transportation, solar power, nuclear power, fusion power

Hyperloop has been proposed as a carbon-free, zero-emission technology for ultra-high-speed transportation. The original Hyperloop Alpha Paper's concept suggested solar power as an energy supply option.

However, latest advancements in the energy sector, particularly in nuclear power and prospective fusion technologies, opened new discussions on the feasibility of alternative power supply scenarios for Hyperloop systems. This research presented a comparative assessment of nuclear, solar, and prospective fusion power supply scenarios for a Hyperloop transportation system on the circle Latvia route, California San-Francisco-Los-Angeles and Mumbai-Pune routes. In scope of study, Swisspod, HARDT, Nevomo, TUM and other Hyperloop projects were analysed. System dynamics model was developed, and simulations were conducted to compare the selected power supply scenarios over a one-year period. The

analysis identified key economic performance metrics among the selected power supply scenarios. The results highlighted the potential of prospective fusion power for Hyperloop transportation systems alongside more established nuclear and solar alternatives. The research contributes to the European Green Deal and UN Sustainable Development Goals SDG-9, SDG-11, SDG-12, and SDG-13.

TRANSPORT INNOVATIONS AND SUSTAINABLE URBAN MOBILITY IN BANGLADESH: A QUALITATIVE ANALYTICAL ASSESSMENT

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Keywords: Transport innovation, sustainable transportation, urban transport, Bangladesh

Transport innovation is increasingly central to sustainable urban development in rapidly growing cities of developing countries such as Bangladesh. Escalating congestion, deteriorating air quality, rising greenhouse gas emissions, and inadequate transport infrastructure highlight the urgency for integrated mobility solutions. Although prior studies examine individual technologies or isolated policy measures, limited research provides a holistic assessment of transport innovations through an integrated sustainability lens. This study addresses that gap by developing a Bangladesh-specific analytical framework that evaluates major transport innovations—electric vehicles, metro rail, bus rapid transit, ride-sharing platforms, intelligent traffic management systems, and non-motorized transport—across four dimensions: environmental impacts, socioeconomic implications, implementation barriers, and policy and institutional requirements. Findings indicate that these innovations can significantly reduce emissions, lower fossil-fuel dependence, improve public transport efficiency, decrease congestion, and enhance accessibility and urban livability. However, progress is hindered by infrastructure deficits, high capital costs, weak regulatory enforcement, limited institutional coordination, technological constraints, and low public acceptance. The comparative analysis shows substantial variation in sustainability outcomes and implementation needs, underscoring that no single intervention can resolve Bangladesh’s multifaceted mobility challenges. The study’s key contribution is an integrated analytical framework linking transport innovations with sustainability outcomes and policy responses in a developing-country context. It offers a structured foundation for future research and evidence-based guidance for policymakers pursuing coordinated, long-term strategies for sustainable urban mobility transitions.

SMART ALGORITHMS FOR DYNAMIC MULTI-LEVEL ORGANIZATIONAL MODELLING IN TECHNICAL SYSTEM DESIGN

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Keywords: Dynamic organizational modelling, hyperdimensional data clustering, multi-level systems, smart predictive algorithms, technical system design

Contemporary production and organizational systems operate under conditions of increasing environmental volatility, technological complexity, and demand uncertainty. In such contexts, the evaluation of system performance cannot be limited to static efficiency measures or short-term cost optimization. Instead, performance must be assessed dynamically, accounting for the system's ability to adapt, reconfigure, and remain viable over time. Existing predictive and management approaches often focus on isolated variables and deterministic relationships, while multi-level interaction structures, dynamic dependencies, and bounded instability phenomena remain underrepresented in organizational analysis and predictive modelling. The aim of this research is to outline a dynamic multi-level modelling approach combining the Multi-Level Success Factor (MLSF) framework with Hyperdimensional Data Clustering (HDC) methods within a Multi-Level Perspective (MLP). The proposed approach enables the identification of dynamic interaction patterns, evolving organizational states, and stability–instability transitions in complex organizational and production systems.

Empirical investigations conducted in the context of technical system design and production-related organizational processes demonstrate that the proposed approach improves the interpretation of dynamic dependencies and reveals interaction structures that are difficult to identify using conventional static analytical models. In particular, the integration of HDC-based clustering supports the analysis of evolving system states and adaptive behaviour patterns. The proposed modelling approach contributes to smart predictive modelling and adaptive organizational analysis by integrating dynamic multi-level interaction structures into decision-support and management-oriented analytical environments.

TraC-TOR: EFFICIENT 32 BIT LOAD CHANGE ENCODING FOR PREDICTIVE MAINTENANCE IN TRANSPORTATION DIESEL ENGINES

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Keywords: Load change encoding, predictive maintenance, TraCTOR, resource-constrained ECU

Predictive maintenance for large diesel engines requires usage data that reflects real operating behaviour more precisely than operating hours or mileage alone. Many wear mechanisms are linked to load changes, temperature profiles, and operating events such as engine starts.

In practice, however, engine control units (ECUs) offer only limited memory and computational resources; in the studied case, approximately 3 MB of memory are available, and signal logging must adhere to a strict 32-bit integer logic.

This paper introduces TraC-TOR (Transition Counting – Time and Order Related), a wear-oriented signal condensation method that encodes each detected load change of a pre-classified signal into a single 32-bit data label. Each load change is characterised by the start and end class as well as dwell times in both classes and the transition time between them, while the chronological order of all load changes is preserved.

The method is evaluated using on-board diagnostics data from a Golf 7 TDI as a methodological proxy for large engines. Three signals with distinct characteristics are considered: vehicle speed as a technical comparison signal, coolant temperature as a sluggish signal, and accelerator pedal position as a highly volatile signal. TraC-TOR's storage behaviour is compared with two simple lossless run-length encodings (RLE32, RLE16), applied to the same classified signals.

The results indicate that TraC-TOR can store more than 2000 operating hours of multiple signals within the 3 MB memory budget under strict 32-bit constraints and is consistently more storage-efficient than RLE32 for speed and throttle-position signals. Compared with RLE16, TraC-TOR's advantage in memory efficiency speed and throttle-position signals shrinks considerably, while causing higher memory usage for the coolant temperature signal. Overall, the main contribution of TraC-TOR lies not in maximum compression, but in providing a storage-efficient, wear-oriented, and directly interpretable representation of load changes that is compatible with existing ECU architectures.

INVESTIGATION OF ELECTRIC VEHICLE AC CHARGING EFFICIENCY AS A FUNCTION OF CHARGING RATE

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Keywords: Battery electric vehicle, AC charging, on-board charger, charging losses, charging efficiency

This paper examines the grid-to-battery efficiency of AC charging of a battery-electric vehicle at different charging currents and supply configurations. In this study, charging rate refers to the electrical operating point established by the selected AC current and supply configuration, rather than to the battery C-rate. Experimental measurements were carried out on a 2021 Volkswagen ID.3 Pro Performance equipped with an 11 kW three-phase on-board charger. Charging sessions were performed at current settings from 8 to 16 A using a single-phase portable charging device and a three-phase AC charging station. The energy drawn from the AC supply was compared with the increase recorded by the vehicle's high-voltage-battery energy counter.

The measured efficiencies differed between the two investigated charging arrangements. With the single-phase arrangement, efficiency ranged from 86.63% to 87.78%, whereas the three-phase arrangement yielded 95.22-96.31%. Within the three-phase series, measured efficiency remained close to 96% at current settings of 10 A and above, while the two lowest-current sessions showed somewhat higher relative losses. Because the two arrangements used different charging devices and integrated meters and each operating point was tested once, these differences are treated as descriptive associations and cannot be attributed exclusively to phase configuration or charging current.

The results provide model-specific experimental evidence for the Volkswagen ID.3 and illustrate the importance of considering the complete charging arrangement and OBC operating point when evaluating AC charging losses. The study is intended as a model-specific validation and extension of efficiency trends reported in previous multi-vehicle investigations, while its limitations define the need for repeated measurements with common calibrated instrumentation.

SHAPING THE START-UP OF A HYDROSTATIC TRANSMISSION USING PROPORTIONALLY CONTROLLED VALVES

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Keywords: Transport vehicles, aerospace technology, hydraulic drive, control, signal, pressure pulsation

This paper investigates dynamic pressure surges that occur during the start-up of hydrostatic transmissions commonly used in machinery, as well as in land and aerospace transport vehicles. A throttle-controlled hydrostatic transmission equipped with a proportional directional control valve was analysed to determine how variations in the control signal profile affect the magnitude and progression of these surges. The results obtained were compared with those of a hydrostatic transmission system using a conventional

electrically controlled directional control valve. The findings highlight the inherent limitations of hydrostatic drives and demonstrate the potential of control signal optimisation to mitigate adverse pressure effects. The developed simulation model provides a useful tool for improving start-up control strategies, enabling more effective shaping of pressure waveforms and reducing peak pressure values.

A RISK-BASED RELIABILITY INDICATOR MODEL FOR ASSESSING MILITARY MOBILITY CORRIDORS IN CENTRAL EUROPE

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Keywords: Military mobility, transport corridors, reliability, risk indicators, corridor-node systems, defence logistics, resilience, Central Europe

Military mobility has become a decisive condition of European defence readiness, yet corridor assessment remains fragmented between infrastructure, administrative, logistics, digital and security perspectives. This paper develops the Military Mobility Corridor Risk and Reliability Model (MM-CRRM), a non-sensitive semi-quantitative tool for assessing the risk-adjusted reliability of military mobility corridors in Central Europe. The model treats a corridor as a system-of-systems composed of routes, nodes, procedures, transport and handling assets, digital services and governance arrangements. It integrates six dimensions and applies likelihood-impact-controllability scoring, scenario weights and a bottleneck criticality index. The model is demonstrated through three anonymised corridor archetypes under rapid reinforcement, sustained logistics and hybrid disruption scenarios. The contribution is to connect transport reliability research with defence logistics and security-of-supply debates, while offering a practical diagnostic approach for prioritising corridor bottlenecks without dis-closing operational routes or sensitive infrastructure vulnerabilities.

HYBRID-ELECTRIC STOL DRONE MOTHERSHIP FOR BALTIC FOREST FIRE DETECTION

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Keywords: Drones, Baltic forests, STOL aircraft, wildfire, monitoring

Europe is a forested continent, with forests covering 40-45% of its land area, and according to statistics, the 2025 fire season was the worst on record in the European Union. While monitoring systems exist, current surveillance methods experience limited endurance and delayed response time. This paper proposes and develops the preliminary design of a two-seat hybrid-electric short takeoff and landing (STOL) aircraft that is capable of coordinating and deploying UAV drones for distributed wildfire surveillance in Baltic forest regions. As well, as investigates the feasibility of converting a Cessna 172S aircraft into this hybrid-electric STOL drone vehicle, which will serve as a “mothership” for a reconnaissance and communication platform. The drones will function as sensing nodes for low-altitude thermal imaging, smoke penetration analysis, and high-resolution mapping.

We evaluate and analyze the proposed design using aerodynamic analysis based on the Vortex Lattice Method, alongside analytical calculations of lift, drag, take-off performance and power requirements. Based on the calculated power demand, we select a suitable hybrid propulsion system, whilst

ensuring it meets the modified aircraft's performance requirements. The modified design has achieved a reduction in take-off distance of ... per cent, an increase in the lift coefficient of ... per cent, a take-off power requirement of approximately 167 kW, and the introduction of a hybrid propulsion system with a maximum power output ... times greater than that of the original design. Ultimately, this innovative design, indicate that the modifications undertaken improve performance compared to the original design, transforming it for the short-field performance, making it more suitable, versatile, efficient and responsive for monitoring forest fires.



Intelligent Transport Systems & Technologies

MAPPING RISK MANAGEMENT 'BLACK HOLES' IN TRANSPORT INFRASTRUCTURE MEGAPROJECTS

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Keywords: Transport infrastructure megaprojects, project management, risk assessment, knowledge gaps, regulatory gaps, decision support; infrastructure governance

Transport infrastructure megaprojects increasingly rely on multiple knowledge sources for risk assessment: scientific literature, professional and methodological sources, regulatory documents, risk management guidelines, and project planning tools. The paper addresses railway, road, port, and multimodal infrastructure contexts, while railway safety regulation is used as one illustrative example of a mode-specific regulatory framework. Each source describes risks at a different level of detail; therefore, hidden knowledge gaps, or 'black holes', may emerge at the project level between what is theoretically recognised, practically addressed, formally required, and methodologically implemented. The aim of this study is to develop a structured approach for identifying such gaps in transport infrastructure megaprojects. The theoretical foundation is based on organisation theory and structured document analysis. The methodology involves mapping risk related statements across scientific, professional, regulatory, and methodological sources and classifying them according to risk domain, project life-cycle phase, source type, evidence level, organisational responsibility, and relevance to decision-making. The result is a framework that helps identify risk management 'black holes' and improve transparent, auditable, and project-level risk management practice in complex transport infrastructure megaprojects.

A CONCEPTUAL FRAMEWORK FOR STRUCTURING MISSION-CRITICAL TRANSPORT: INSIGHTS FROM INSTITUTIONAL AND SCIENTIFIC LITERATURE

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Keywords: Mission-critical transport, conceptual framework, protected function, criticality driver, transport requirement

Transport becomes mission-critical when continuity of a societal or state function depends on transport performance, yet such problems are usually examined within specialised fields. This study develops a cross-domain conceptual framework from 34 institutional documents and 26 scientific papers. The analysis shows that mission-criticality is defined by functional dependence, while mission domain, activation logic and response phase describe distinct contextual dimensions. The protected function and its criticality driver establish the basis for the transport requirement, which must be realised through a feasible transport-system configuration under prevailing operating conditions and governance arrangements. The resulting framework connects institutional reasoning with operational transport analysis and provides a common structure for examining mission-critical transport across societal and state functions.

A STUDY ON IMPROVING WAREHOUSE OPERATIONS IN LITHUANIAN LOGISTICS COMPANIES THROUGH THE IMPLEMENTATION OF AUTOMATED SOLUTIONS

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Keywords: Logistics companies, warehousing processes, automation

The implementation of automated technologies in the warehousing processes of logistics companies can significantly increase operational efficiency, as it simplifies goods receipt, internal warehouse movement, order picking, dispatch, and the management of related documentation. The aim of the study is to determine the factors determining the efficiency of automation of warehousing activities of a logistics company based on multi-criteria assessment.

Automated processes enable smoother information exchange between different departments of the company, reduce the need for manual labor, lower the likelihood of errors, and increase work speed. All of this ensures that the end customer receives goods more quickly, while the company operates more efficiently. A multi-criteria evaluation method was used to conduct the study. The study revealed the factors determining the efficiency of automation of warehousing activities in a logistics company. Considering these aspects, the automation of warehouse processes is essential for improving warehouse performance, increasing competitive advantages, and enhancing profitability. To avoid existing challenges, it is necessary to implement automated solutions that significantly improve warehousing processes, reduce the number of errors, and provide companies with a competitive edge.

INVESTIGATION OF THE DEPENDENCE OF QUAD BIKE STABILITY ON RIDER SEATING POSITION

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Keywords: Quad bike, vehicle stability, rider position, uphill travel, downhill travel

This paper examines the dependence of quad bike (ATV) stability on rider seating position. Stability is a major factor in the safety and controllability of these vehicles, particularly because quad bikes have a relatively high centre of gravity, narrow track and short wheelbase. These characteristics make them sensitive to changes in mass distribution, and therefore rider posture can substantially affect stability.

The aim of the study is to evaluate how three rider seating positions affect the longitudinal stability of a quad bike when ascending and descending slopes. The investigated postures are neutral, leaning forward and leaning backward. The analysis is based on fundamental principles of mechanics, including the position of the combined centre of gravity, axle-load distribution and tipping moments. The centre-of-gravity coordinates and their variation were determined experimentally for a CFMOTO CFORCE 450L quad bike.

The results show that rider seating position has a substantial effect on the calculated longitudinal stability limits. Leaning forward improves stability during ascent, whereas leaning backward is beneficial during descent. Conversely, an inappropriate posture reduces the available stability margin, especially on steep slopes.

The findings demonstrate that correct rider positioning is an effective and practical means of improving quad-bike stability without additional technical modifications. The results can be applied in rider-training programmes and in the development of safety recommendations.

METHODOLOGY FOR QUANTITATIVE ASSESSMENT OF TECHNICAL AND TECHNOLOGICAL COMPATIBILITY FOR INTERNATIONAL RAIL FREIGHT CORRIDORS: THE CASE OF UKRAINE-LITHUANIA

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Keywords: Technical and technological interoperability, railway engineering subsystems, quantitative assessment, spatial–scenario matrix, interoperability index, critical constraints, freight transport chain, cross-border railway corridor

The technical and technological interoperability of international railway freight corridors is determined by the compatibility of infrastructure, rolling stock, operational processes and the interfaces between them. Despite the development of the regulatory framework, methods for the quantitative assessment of these types of functional compatibility remain insufficiently developed. The aim of the research is to develop a method for the quantitative analysis of technical and technological interactions between the components of a railway corridor with classification of the final level of interoperability. The method is based on the calculation of partial interoperability coefficients for the characteristics of infrastructure, rolling stock and operational processes, including line load category, track gauge compatibility, track geometry, traction power supply, operational restrictions and terminal operating processes. The method was applied to three alternative Ukraine–Lithuania railway freight corridors under four operational scenarios. The obtained results demonstrated an increase in the integral interoperability index from the baseline scenario S0 to scenario S3 for all routes and made it possible to identify critical local constraints. The scientific novelty lies in the development of a quantitative method for assessing systemic technical and technological interactions, while the practical significance lies in its application for route comparison and justification of measures for improving infrastructure and freight transportation.

FLEET DECARBONIZATION POTENTIAL OF PUBLIC TRANSPORT: A CO₂ EMISSION ASSESSMENT AND SCENARIO ANALYSIS OF VILNIUS PUBLIC TRANSIT

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Keywords: Public transport, sustainability, decarbonization

Europe’s key objective is to achieve the European Green Deal and climate neutrality by 2050, requiring substantial reductions in greenhouse gas emissions across all sectors, including transport. Public transport plays an important role in urban transport decarbonization, particularly through the transition from internal combustion engine buses to lower-emission technologies. The purpose of this study is to assess the operational CO₂ emissions of the Vilnius public transport fleet and evaluate the potential for fleet decarbonization through alternative vehicle replacement scenarios. The methods used include scientific literature analysis and an applied quantitative case study of the Vilnius public transport system. The results indicate that the greatest CO₂ reduction potential is associated with replacing diesel buses with trolleybuses. However, the analyzed scenarios are hypothetical and based on theoretical calculations, while their practical

implementation is constrained by existing infrastructure, depot capacity, route characteristics, and technological requirements. These constraints provide a basis for further research on the feasibility of public transport fleet decarbonization.

LOW-LATENCY TELEOPERATION ARCHITECTURE FOR AUTONOMOUS MOBILE ROBOTS USING BINARY-ENCODED ROS2 MESSAGES

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Keywords: Autonomous vehicles, teleoperation, round-trip latency, WebRTC datachannels, ROS 2, binary-encoded messages

Autonomous vehicles and mobile robots are increasingly deployed in intralogistics, manufacturing, and public transport. Despite progress in advanced driver-assistance systems and Level 4 autonomy, real deployments still encounter edge cases, perception failures, and safetycritical situations that autonomous systems cannot handle reliably on their own. Full autonomy therefore remains a long-term goal rather than a present reality.

Teleoperation lets a human operator supervise, intervene, or take over when autonomy is no longer sufficient. Its reliability depends heavily on the communication link between operator and robot. Operator performance drops once round-trip latency exceeds roughly 200 to 300 milliseconds, and control becomes unsafe beyond that range: higher delay reduces situational awareness, weakens control precision, and raises the operator's cognitive load. Wireless networks such as Wi-Fi, LTE, and 5G make this worse through variable delay and jitter. ROSBridge, the standard gateway between ROS 1 or ROS 2 and external applications, serializes messages as JSON over WebSocket. It is easy to integrate, but it was designed for interoperability rather than real-time performance: JSON encoding inflates both message size and processing time, which is problematic where low latency is a hard requirement.

This paper proposes a teleoperation architecture that replaces JSON with compact binary-encoded messages carried over modern web transport protocols. We compare WebSockets, WebTransport, and WebRTC DataChannels to identify, which protocol meets the latency demands of real-time teleoperation, and we evaluate the architecture over Wi-Fi and cellular networks by measuring round-trip latency against the thresholds required for safe human-in-the-loop control.

PERFORMANCE AND EMISSION FORECAST OF DIESEL ENGINE USING ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING (AI-ML) TECHNIQUES

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Keywords: Artificial intelligence, machine learning, random forest, artificial neural network, k-nearest neighbors, diesel engine

The increasing demand to replace diesel fuel with current advanced technology has driven the need to develop a predictive tool for diesel engine characterization. In this article, different ML models like Random Forests (RF), Artificial Neural Networks (ANN), Support Vector Machines (SVM), and k-Nearest Neighbors (KNN) are studied to test their predictive accuracy with the experimental results. These are tested at different engine operating conditions, which serve as the input variables for the AI-ML testing, and different performance and emission characteristics are the output variables. Performance is measured in terms of Brake Specific Fuel Consumption (BSFC) and Brake Thermal Efficiency (BTE). The emission forecast is based primarily on CO, NO_x, HC, and smoke results. This article analyzes the AI-ML techniques in terms of coefficient of determination (R^2), root mean square (RMSE), and mean absolute error (MAE). Various studies have reported that the AI-ML models outperformed traditional linear regression models, achieving 95-99% efficiency when compared to the experimental results. This article provides the future scientists with a structured overview of the artificial intelligence-machine learning techniques and their efficiency to predict engine performance and emissions while reducing the operational cost and increasing the overall efficiency and effectiveness of the use of AI in engine testing.

RISK REDUCTION IN MARITIME SINGLE WINDOW SYSTEM: THE ROLE OF CENTRALISED DIGITAL REPORTING

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Keywords: Maritime Single Window (MSW), risk reduction, digital maritime reporting

Transport systems are undergoing rapid digital transformation, where the effective management of data is central to operational safety, efficiency, and coordination. Within this context, Maritime Single Window (MSW) systems form a key component of wise transport systems by enabling standardised and centralised data exchange across stakeholders. The Finnish NEMO system, developed under the European Maritime Single Window environment (EMSWe), aims to harmonise reporting practices and reduce fragmentation in maritime information flows.

This study examines how digitalisation and system centralisation contribute to risk reduction in maritime reporting environments. The research adopts a qualitative approach, combining stakeholder perspectives, document analysis, and observations from system development and testing phases. A structured Key Performance Indicator (KPI) framework is used to assess key dimensions of system performance, including data accuracy, reporting time, and process consistency. These indicators provide a basis for evaluating how digital reporting systems can improve reliability and support coordinated decision-making.

The findings indicate that centralised digital reporting, as implemented in the NEMO system, is anticipated to reduce operational risks associated with fragmented reporting practices by improving data consistency, reducing duplication, and enhancing transparency. Centralised data submission and automated information sharing are expected to minimise the likelihood of errors caused by manual processes and enable more consistent communication between stakeholders. In addition, harmonised reporting standards under EMSWe are expected to support interoperability and reduce uncertainty in regulatory compliance. As the NEMO system has not yet reached operational deployment, these findings should be interpreted as anticipated rather than demonstrated outcomes. The study suggests that digital maritime reporting systems have the potential to strengthen the reliability and resilience of transport operations when supported by effective governance and stakeholder alignment.



Higher Education & Reskilling

EPISTEMIC AGENCY AS A CORE UNIVERSITY COMPETENCE IN THE AGE OF GENERATIVE ARTIFICIAL INTELLIGENCE

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Keywords: Epistemic agency, generative artificial intelligence, higher education, knowledge lifecycle, AI literacy, cognitive outsourcing, knowledge depth, university competence

Generative artificial intelligence (GenAI) now supports searching, summarizing, explaining, coding, and writing at a scale that weakens the assumption that a submitted academic product reflects a student's internal understanding.

The aim of this study is to develop a compact conceptual-operational framework for understanding and assessing student epistemic agency as a core university competence in AI-mediated higher education. This paper argues that AI literacy, while necessary, is not sufficient as a guiding educational goal, and proposes a broader competence: epistemic agency — the learner's capacity to intentionally initiate, organize, verify, internalize, apply, revise, and responsibly communicate knowledge with human and AI partners. It formalizes the knowledge lifecycle as an educational object, defines the cognitive depth gap between AI-assisted performance and internal mastery, and introduces the Knowledge Depth Index and Epistemic Agency Index as conceptual-operational tools, with four complementary assessment modes: no-AI individual tasks, AI-assisted tasks, error-detection tasks, and delayed reconstruction tasks. The results provide a structured basis for curriculum design, assessment rubric development, and program-level AI policy.

The university's mission in the GenAI era is not only to train competent AI users, but to develop students who remain responsible subjects of knowledge.

NAVIGATING THE DIGITAL SHIFT: LABOR MOBILITY, SKILLS GAPS, AND INFRASTRUCTURE DEVELOPMENT IN SUB-SAHARAN AFRICA

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Keywords: Digital infrastructure, labor reallocation, Sub-Saharan Africa, economic inclusion

This study examines how digital infrastructure shapes labor reallocation across agriculture, industry and services sectors in Sub-Saharan Africa. Digital connectivity is quickly changing labor markets in the region, with workers fleeing traditional sectors, especially agriculture, and increasingly entering digitally mediated sectors, such as the services sector.

The main objective of the study is to explore reallocation channels with the goal of understanding how digital infrastructure plays a role in achieving both economic diversification and sustained development in Sub-Saharan Africa that is, analyzing how digital connectivity drives labor reallocation across agriculture, industry, and services sectors.

The research involves a combination of surveys, interviews, and secondary data collection. Surveys and semi-structured interviews are used to obtain the primary data. The use of surveys, interviews, and secondary data provides a more robust and nuanced understanding of the phenomenon compared to relying on a single data source. Triangulation of data from different sources enhances the credibility of findings.

There exists a significant positive relationship between more internet access and labor migration, particularly into cities. However, rural areas do not benefit from improved connectivity and have fewer digital skills. Schools of thought focus on closing the historic and ongoing equity gaps between the

economic have-nots and budding digital divides. This study also calls attention to the emerging demand for digital literacy programs and policies that uplift infrastructure in underserved spaces.

The paper, therefore, contributes towards answering the question of how transformation can be achieved in Sub-Saharan Africa in a way that is inclusive for most of the population, especially the youth. It is undertaking this study that the actual value of digital infrastructure can be noted and valued. Such a viewpoint shows the absolute necessity of more digital infrastructure in Sub-Saharan Africa in addition to connecting the labor markets to actual skill so as to bridge the existing development gaps in the region.

The results obtained allows for the formulation of recommendations for the development of economic policies aimed at encouraging the investment in and proliferation digital infrastructure by policy makers to foster labor movement from agricultural to industrial and tertiary sectors. These outlines the need for digital literacy programs and investments in infrastructure in underserved areas to ensure inclusive growth. This emphasizes the importance of equitable development alongside technological advancement.

FROM DIGITAL GAPS TO ECONOMIC GAINS: E-COMMERCE, LABOR REALLOCATION, AND SUSTAINABLE DEVELOPMENT IN SUB-SAHARAN AFRICA

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Keywords: Labor productivity, e-commerce, digital platforms, Sub-Saharan Africa, digital literacy

Nowadays, e-commerce mobilises relevant actors, notably businesses, to play an innovative role in digital technologies' adoption, thereby fostering sustainability efforts within the broader community. Other actors such as government offices, policymakers and authorities also act in promoting ecommerce adoption, leading to sustainable transitions towards the achievement of the United Nations Sustainable Development Goals (UN-SDGs). Notably, the achievement of SDG 9: Industry, Innovation, and Infrastructure and SDG 10: Reduced Inequality.

To foster the exchange of ideas, experiences, and successful sustainability practices, this research aims to analyse the effect of e-commerce adoption on labour productivity and job creation in Sub-Saharan Africa with a specific focus centred on the urban-rural dynamics in attaining sustainable growth. Urban areas experience drastic productivity and employment recovery due to more connectivity opportunities and digital activity than rural hubs as a result of infrastructure and a higher knowledge of basic digital skills.

The research presented in the paper, through case studies and extensive data analysis, underscored the importance of selective policies and specifically focused investments to enhance rural infrastructure development and digital literacy to enable broader access to the opportunities for sustainable economic development offered by e-commerce.

On the other hand, rural regions were significantly impacted by issues such as low connectivity and access to digital tools that restricted these areas from fully harnessing e-commerce platforms. Likewise, taking measures in the research related to actionable expansion e-commerce could create more conditions to promote digital inclusivity.

The following are practical implications of the research. For instance, if Sub-Saharan African nations embrace e-commerce adoption and its full potential, it translates into more economic empowerment for both the region and its people. When the territory gets empowered more in e-commerce adoption, it will gradually impact labour productivity. Additionally, when labour productivity is improved, it will significantly enable the inhabitants to have more disposable income, reduced inequality, higher standards of living and various SDG achievements.

The results obtained allow for the formulation of recommendations by stakeholders and policymakers in the development of e-commerce adoption policies aimed at encouraging e-commerce ecosystems, which boost labour productivity and job creation. Also focusing on the urban-rural divide and inclusive e-commerce adoption with Sustainable Development Goals alignment is vital for achieving SDGs 9 (Industry, Innovation, and Infrastructure) and 10 (Reduced Inequalities), respectively.

THE PADL INDEX AS A FRAMEWORK FOR ASSESSING PEDAGOGICAL, ANALYTICAL, AND DIGITAL LITERACY IN FUTURE-READY UNIVERSITIES

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Keywords: The PADL index, pedagogy, learning analytics, digital literacy, future-ready universities, higher education institutions, management

This study introduces the PADL Index as a Framework for Assessing Pedagogical, Analytical, and Digital Literacy in Future-Ready Universities. The PADL concept has been formally registered under Certificate of Registration TX-9-461-809 with the United States Register of Copyrights and Directory, thereby supporting its originality as an intellectual contribution. While HEIs invest in digital transformation, artificial intelligence, and learning analytics, there is a significant research gap in how faculty readiness is measured across the integrated dimensions of pedagogy, analytics, and digital literacy. Existing research separately addresses technology adoption, teaching effectiveness, digital competence, and more; however, it does not capture the multidimensional literacy required for future-ready universities. In this research, the author aimed to conceptualize and validate the PADL index as a structured assessment framework that evaluates faculty and institutional readiness. The main purpose is to provide academic and educational decision-makers in HEIs with a practical tool to diagnose capability gaps using data-driven, evidence-based information. This research used a conceptual framework development approach. The systematic literature review was conducted on pedagogical competence, learning analytics readiness, digital literacy, and higher education transformation. This research was limited to reliability, and generalizability. However, the novelty is a copyrighted, multidimensional index that integrates pedagogy, analytics, and digital literacy into a single assessment structure. The PADL index application offers HEIs a diagnostic and strategic planning for long-term institutional innovation.

A DATA-DRIVEN SOCIAL MEDIA MARKETING COMMUNICATION MODEL FOR REDUCING DATA UNDERUTILISATION IN HIGHER EDUCATION

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Keywords: Social media marketing, higher education institutions, big data, communication model

The digitalisation of higher education has substantially increased the amount of data produced through social media. However, universities do not always transform these data into actionable communication decisions, resulting in the underutilisation of available analytics, referred to in this study as big data waste. The aim of this study is to develop a data-driven social media marketing communication model that converts social media, and content indicators into adaptive communication actions. A mixed-method design was applied to 14 Baltic States universities. Ward's hierarchical clustering and k-means crossvalidation were used to classify the universities according to international student numbers and Times Higher Education ranking positions. Facebook and YouTube performance indicators were subsequently analysed within the resulting clusters, together with content characteristics, keyword density, and destination-link alignment. Four stable university clusters were identified.

The results show that audience growth does not necessarily produce sustained interaction and that communication priorities differ according to institutional and digital performance tendencies. The proposed integrated model links performance-based actions Maintain, Reinforce, Adapt, and Revise to four cluster-specific priorities: engagement, differentiation, continuity, and coherence. The model reduces big data waste by converting routinely collected communication data into structured managerial decisions.

PROMPT AS DIGITAL COMMUNICATION: MATCHING FUNCTIONAL MODELS TO TYPES OF LEARNING TASKS

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Keywords: Generative AI, prompt, discourse analysis, Bloom's taxonomy, learning tasks, functional models

The rapid diffusion of generative artificial intelligence has transformed prompting from a technical procedure into a new form of human–AI communication. Although prompt engineering has become an increasingly important field of research and practice, existing approaches remain largely focused on prompt formulation and provide limited theoretical guidance for de-signing communication according to the nature of the task being performed. The aim of this study is to develop a communicative model for prompt design that accounts for the relationship between learning tasks, cognitive processes, and human–AI communication. The model is grounded in an adapted interpretation of Bloom's Taxonomy, contemporary classifications of knowledge, and discourse analysis, conceptualizing prompts not as isolated textual instructions but as communicative acts embedded in broader processes of human–machine partnership. Accordingly, cognitive–communicative alignment provides the basis for effective matching between learning tasks and prompts.

Educational interaction serves as the primary analytical context for illustrating and validating the proposed model because it makes explicit the relationships among task structure, cognition, communication, and learning outcomes. Within this context, the article develops specific functional communicative models for prompt design and demonstrates their practical implementation through an analytical–dialogical case study. The findings suggest that the effectiveness of human–AI interaction depends not on universally effective prompts but on cognitive–communicative alignment between the nature of the task and the communicative organization of the interaction. The proposed model may provide a conceptual basis for designing communication with generative AI not only in education but also in other domains that require complex human–AI collaboration.



Aviation Innovation & Safety Culture

AERODYNAMIC INTERACTIONS AND FLIGHT DYNAMICS OF OVER-ACTUATED eVTOL AIRCRAFT IN TRANSITION FLIGHT

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Keywords: eVTOL, transition flight, rotor rotor interference, over actuated systems, control allocation, Linear Parameter Varying, flight dynamics, urban air mobility, wake interactions, aerodynamic coupling

The aerodynamic interactions and flight dynamic behaviour of overactuated electric vertical takeoff and landing (eVTOL) aircraft in transition flight reflect the simultaneous operation of rotor rotor, rotor wing, and rotor wake body interference phenomena across a continuous speed corridor in which neither classical rotorcraft theory nor fixed wing aerodynamics alone provides an adequate predictive basis. This paper presents a comprehensive theoretical and computational investigation into these coupled phenomena for a representative eight rotor tilting wing eVTOL configuration, spanning advance ratios from $\mu = 0$ to $\mu = 0.55$ and rotor tilt angles from 0° to 90° .

The investigation employs a high fidelity multidisciplinary modelling framework integrating unsteady blade element momentum theory with Reynolds Averaged Navier–Stokes simulation augmented by detached eddy simulation closures. The analytical architecture combines a trajectory scheduled Linear Parameter Varying framework for flight dynamic characterisation, a Sequential Quadratic Programming control allocation formulation with time varying actuator effectiveness matrices, and an H_∞ robust synthesis procedure for closed loop stability analysis across the full transition envelope.

Five primary aerodynamic interaction phenomena are identified and characterised: systematic thrust and torque degradation from partial wake reingestion in partially tilted configurations; periodic pitching moment oscillations at twice the blade passage frequency arising from mutual induction velocity fields between longitudinally staggered rotor pairs; spanwise interference between overlapping rotor disks not captured by quasi steady momentum models; ground effect dissolution at intermediate altitudes; and a bounded dynamic instability corridor centred near $\mu \approx 0.15$ – 0.25 , in which coupled roll yaw heave modes exhibit damping ratios falling below $\zeta = 0.15$. These phenomena are shown to generate non minimum phase inversion problems at tilt transition inflection points and transient decoupling of translational and rotational dynamics not addressed by existing control allocation methods.

The study advances a physically grounded and computationally tractable methodology for the integrated treatment of these phenomena, providing the analytical infrastructure and design guidelines necessary for safe transition flight in urban air mobility operations.

A THERMODYNAMIC AND AERODYNAMIC PERFORMANCE COMPARISON OF TWO CFM TURBOFAN ENGINES OF EQUAL RATED THRUST

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Keywords: CFM56-5B4, LEAP-1A26, turbofan cycle analysis, bypass ratio, TSFC, propulsive efficiency, engine comparison, A320

This paper presents a rigorous, thermodynamic cycle analysis comparing two CFM International turbofan engines of nominally equal rated thrust (120.1 kN): CFM56-5B4 powering the Airbus A320neo and the next-generation LEAP-1A26 powering the A320neo. Both engines are modelled under identical cruise conditions ($M_0 = 0.85$, 35 000 ft ISA). The analysis predicts a cruise TSFC of $18.4 \text{ mg N}^{-1} \text{ s}^{-1}$ for the CFM56-5B4 and $13.8 \text{ mg N}^{-1} \text{ s}^{-1}$ for the LEAP-1A26, a 25% reduction. The primary driver is the LEAP engine's near-doubled bypass ratio (11.0 vs. 5.7), which increases the propulsive efficiency from 0.61 to 0.73. Higher overall pressure ratio (40 vs. 32.6) and improved component efficiencies contribute to a further gain in thermal efficiency (0.58 vs. 0.52). These results are consistent with the 15% fuel-burn improvement reported by CFM for the LEAP over the CFM56 (0.58 vs. 0.52).

A SIMPLIFIED ANALYTICAL ASSESSMENT OF WAKE-VORTEX EFFECTS ON AIRCRAFT STABILITY DURING TAKEOFF

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Keywords: Aircraft Wake Vortex, disturbed air environment, aircraft stability

The airflow over a finite wing is inherently three-dimensional. The characteristics of the disturbed flow within the wake vortex field and its spatial behavior follow defined aerodynamic laws and depend on the aircraft's performance characteristics, its flight configuration, as well as the wake vortex lifetime. During takeoff or landing, an aircraft may encounter wake turbulence when vortices generated by a preceding aircraft linger over or move slowly relative to the runway centerline. This article provides an analysis of aircraft behavior during takeoff, assuming that the subject aircraft encounters the wake turbulence generated by a preceding aircraft. The analysis utilizes simplified aerodynamic loading models for the wing, accounting for the presence of a lingering vortex localized over the runway.

EFFECT OF COMPOSITE MATERIAL SELECTION ON THE ACTIVE TWIST PERFORMANCE OF HELICOPTER ROTOR BLADES

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Keywords: ANSYS, rotor blade, piezoelectric, twist

This paper presents a concept of active twist for main rotor blade as a means of reducing noise, vibration, and fuel consumption during flight. The study investigates the use of piezoelectric actuators embedded within the blade skin, which induce controlled torsional deformation of the blade under the application of an electric field. By solving the optimal design problem, the blade's internal cross-section geometry is determined in order to achieve the maximum twist angle. Numerical analysis of the blade was performed using the ANSYS software. The optimization was carried out for blades with different combinations of spar and skin materials, including GFRP and CFRP composites. For all optimized models, nearly identical twist angles of 5 degrees were achieved within the design constraints.

PRELIMINARY DESIGN OF A STOL AIRCRAFT FOR REMOTE AREA OPERATIONS

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Keywords: STOL aircraft, aircraft sizing, aerodynamic polars, CS-23 regulations, OpenVSP validation

Traditional emergency medical services (EMS) face a critical challenge in transporting patients from remote locations within the “Golden Hour”. This project presents the preliminary aerodynamic and structural design of a multi-mission Short Take-Off and Landing (STOL) utility aircraft. Configured as a high-wing monomotor with a specialized high-lift NACA 4412 airfoil and an integrated rear cargo ramp, the airframe is optimized for steep approaches and safe landings on unprepared runways. Computational validation via XFLR5 and OpenVSP confirms a maximum 3D lift coefficient (CL_{max}) of 1.40 and a ground roll performance of 172 m under CS-23 structural guidelines ($n = 3.8g$).

PUBLIC-DATA-INFORMED SCENARIO BENCHMARKING FOR AVIATION-FUEL PROCUREMENT UNDER SUPPLY AND SAFETY COST STRESS

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Keywords: Aviation-fuel procurement, scenario simulation, supply disruption, sustainable aviation fuel, CVaR

Regional airlines face fuel-price exposure, sustainable aviation fuel (SAF) obligations, and disruption risk, but public data rarely disclose airline fuel contracts, delivered airport prices, or supplier allocations. This paper develops a public-data-informed scenario benchmark for aviation-fuel procurement under that observability constraint. The benchmark combines open trade, activity, regulatory-reference, and official aviation-stress sources with explicit proxy and synthetic-shock assumptions, then compares no-buffer, static-buffer, and shock-aware buffer policies over 5,000 paired 12-month paths. A public-data-informed scenario benchmark can be constructed for aviation-fuel procurement using open trade, activity, regulatory-reference, and official aviation stress observations, provided the resulting outputs are interpreted as proxy-based benchmark results rather than observed airline transaction outcomes. In the primary Experiment A configuration, F1 lowers mean net cost relative to B0 by 40.67 normalized cost-index units, or approximately 0.451% of the B0 mean, with a paired 95% interval from -45.11 to -36.20. Against the strongest eligible static-buffer baseline, however, F1 is higher by 14.34 cost-index units, or approximately 0.160% of the B1 mean, with a 95% interval from 12.95 to 15.76. CVaR95 point estimates are lower for F1 than for B0 and B1, but no paired CVaR95 confidence interval was produced, so the tail-risk hypothesis remains inconclusive rather than supported. The main contribution is therefore a reproducible negative-result benchmark: adaptive buffering improves on no-buffer but does not automatically dominate a transparent static buffer under the approved public-data proxy model.

STARLINK IN-FLIGHT CONNECTIVITY AS A DRIVER OF PASSENGERS' GROWTH IN COMMERCIAL AVIATION

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Keywords: Starlink, in-flight connectivity, airline strategy, passenger experience, sustainability in aviation, low earth orbit satellites

The commercial aviation industry is undergoing rapid digital transformation, and in-flight connectivity is increasingly shifting from an optional passenger service to an important part of the travel experience. The current research aims is evaluation of the impact of Starlink in-flight connectivity implementation in commercial aviation on passenger experience and airline strategic value, while examining its role in supporting sustainability-oriented airline strategies. Recent developments in Low Earth Orbit satellite constellations, particularly Starlink, may significantly improve the quality of onboard connectivity. The research combines qualitative and quantitative analysis. In addition to a review of academic literature, empirical data were collected through a passenger survey involving 471 respondents. The survey gathered demographic information such as age group, travel purpose, and flight type (short-haul or long-haul), as well as passenger attitudes toward internet availability, connection quality, and airline choice. The research analysis the technological development of in-flight connectivity, examine the relationship between high-speed connectivity, passenger experience, satisfaction and airline choice. In addition, semi-structured interviews were conducted with 4 senior aviation industry managers to evaluate the strategic value of Starlink in-flight connectivity from both passenger and airline perspectives. The interviews explored topics such as return on investment horizon, strategic importance of connectivity, passenger demand, and sustainability considerations. The results suggest that high-performance connectivity such as Starlink may improve passenger satisfaction and influence airline choice, particularly when internet access is fast, stable, and offered free of charge, making.

THE IMPACT OF PSYCHOLOGICAL CAPITAL, WORK ENGAGEMENT AND JOB BURNOUT ON CABIN CREW SERVICE RECOVERY PERFORMANCE

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Keywords: Psychological capital, work engagement, job burnout, service climate, service recovery performance, cabin crew

Service recovery performance is critical in airline operations, where cabin crew members must respond effectively to service failures in dynamic and customer-intensive environments. This study examines how psychological capital influences cabin crew service recovery performance through the mediating roles of work engagement and job burnout, and how service climate moderates the relationship between work engagement and service recovery performance. Data were collected from 120 completed questionnaires administered to flight attendants employed by Vietjet Air and analysed using Partial Least Squares Structural Equation Modelling. The findings show that psychological capital has a positive effect on service recovery performance, both directly and indirectly through higher work engagement and lower job burnout, while service climate strengthens the positive relationship between work engagement and service recovery performance. The model explains a substantial proportion of the variance in service

recovery performance, indicating strong explanatory power. The study contributes to positive organisational behaviour and airline service research by highlighting the combined roles of psychological resources and organisational climate in improving frontline recovery performance.

ASSESSMENT OF AN OPERATOR'S PROPENSITY FOR DECISION-MAKING ERROR TYPES IN AN OPERATIONAL CONTROL LOOP

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Keywords: Human factors, operational control loop, decision making, situational awareness, Type I error, Type II error, signal detection theory, safety

The identification and assessment of operational situations under dynamically changing conditions represent a complex psychophysiological task for human operators and remain insufficiently studied. This paper addresses the problem of how an operator perceives and evaluates the level of hazard or safety of evolving situations within an operational control loop at a specific moment in time. Using a situational analysis framework supported by graphical models, a methodological approach is proposed to describe the operator's process of situation recognition and decision making. Particular attention is devoted to the analysis of behavioural indicators associated with Type I (false alarm) and Type II (miss) decision errors. To quantify an operator's propensity toward a specific error type under uncertainty, Signal Detection Theory (SDT) is applied within the context of statistical hypothesis testing. An experimental study using a computer-based detection task was conducted among students of the Aviation Institute of Riga Technical University to evaluate individual decision bias and sensitivity. The results demonstrate the feasibility of assessing operator tendencies toward different error types and highlight the relevance of the proposed approach for competency-based training and safety management in operational control systems.

PAIRED AIRCRAFT ENGINE RECOVERY AS A COORDINATED SCENARIO-SELECTION PROBLEM

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Keywords: Aircraft engine recovery, paired engines, scenario selection, donor-supported refurbishment, engine part-out, secondary aircraft market

Ageing commercial aircraft are frequently offered on the secondary market as asset packages in which the installed engines represent the principal recoverable value, and are for this reason acquired, and

should be evaluated, together as a single paired asset. Such engines may follow different recovery pathways, including sale as-is, refurbishment, limited-life reuse, donor-supported restoration, and part-out. Evaluating the engines independently can overlook economically beneficial mixed strategies and may lead to double counting when the same component is treated both as donor material and as part of the donor engine’s recovery value. This paper formulates paired aircraft-engine recovery as a coordinated scenario-selection problem. The proposed framework combines engine-level pathway selection with item-level component allocation under technical, documentary, implementation, and economic constraints. Candidate scenarios are screened for admissibility before their expected recovery, pathway costs, acquisition price, and required margin are compared. Donor transfer is considered advantageous only when the avoided external sourcing cost exceeds the transfer expenditure and the recovery value lost by the donor engine. A compact synthetic example demonstrates that the scenario with the highest gross recovery does not necessarily provide the highest package-level margin and that coordinated evaluation may identify a mixed recovery strategy that is not apparent from separate engine valuations. The framework also supports acquire, renegotiate, or reject decisions by linking the preferred pathway to the required margin. The study provides a conceptual foundation for further development based on empirical engine records, uncertainty modelling, and item-level optimisation.

MAPPING VALUES COMMUNICATED BY BALTIC AND NORDIC AIRPORTS: VER-BASED HOMEPAGE BENCHMARKING

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Keywords: Value proposition, airports, value entity recognition, benchmarking, NLP

This paper examines how airports in the Baltic-Nordic aviation market communicate passenger value proposition through their official website texts. Developing the methodology named Value Entity Recognition(VER) and One-Word Approach, previously applied to the value propositions of Middle Eastern airlines, the study annotates value-laden words and short expressions communicated by eight airports: Riga International Airport(RIX), Lennart Meri Tallinn Airport(TLL), Vilnius Čiurlionis International Airport(VNO), Kaunas International Airport(KUN), Oslo Gardermoen Airport(OSL), Helsinki - Vantaa(HEL), Stockholm Arlanda Airport(ARN) and Copenhagen Airport(CPH). The sample reflects two overlapping competitive layers: TLL, VNO, and KUN are considered as direct competitors of Riga for point-to-point passengers in overlapping catchment areas, while HEL, ARN, OSL, and CPH are included as larger Nordic hub competitors and strategic benchmarks. A total of 61 value tokens is annotated (49 unique lemmatized value entities); the extracted entities are distributed across nine semantic clusters - eight clusters are inherited from the airline study, the ninth (Openness and Friendliness) was introduced as a domain adaptation for airports. Quantitative comparison of the groups as reflected by radar charts highlights major differences. Baltic airports focused their communication primarily on Comfort and Convenience, Global and Connectivity and Added Value and Extras semantic clusters and had minimal or no emphasis on Sustainability and Responsibility, Personalization and Rewards or Openness and Friendliness. In contrast, Nordic hub airports provided substantially more balanced and extensive value offerings. The overall vocabulary of values was broadest for ARN (14 unique entities representing 8 of 9 semantic clusters), intermediate for VNO and minimal for KUN. The results confirm the transferability of the VER method from airlines to airports and illustrate the feasibility of using the approach for competitive benchmarking of value communication.

SURROGATE-BASED OPTIMIZATION OF ROTOR BLADE TIP GEOMETRY FOR ENHANCED HOVER EFFICIENCY

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Keywords: Rotor blade, blade vertex interaction (BVI), figure of merit (FOM), computational fluid dynamics (CFD), hover efficiency

The efficiency and acoustic performance of helicopter and unmanned aerial vehicle (UAV) rotors are significantly limited by strong tip vortices and blade-vortex interaction (BVI). This study presents a surrogate-based optimization framework to enhance hover efficiency by systematically modifying rotor blade tip geometry. Through a parametric investigation, design variables including sweep, taper ratio, and anhedral angle are evaluated to optimize the spanwise lift distribution toward a more elliptic configuration. Using high-fidelity computational fluid dynamics (CFD) combined with Latin hypercube sampling, the research quantifies the reduction in tip vortex circulation and its corresponding impact on induced drag. Analytical methods are employed to link these aerodynamic improvements to the rotor's Figure of Merit (FoM), demonstrating significant potential for power savings and enhanced hover performance. The findings indicate that tailored tip modifications can achieve improvements in hover efficiency consistent with established theoretical ranges, offering a robust approach for future rotor design.

HUMAN-CENTERED DIGITAL TWIN FOR DYNAMIC COMPETENCY MANAGEMENT IN AIRPORT GROUND HANDLING OPERATIONS

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Keywords: Ground handling, human-centered digital twin, virtual reality training, competency management, ground handling skills passport, aviation safety

The process of airport ground handling still represents laborious work associated with risks for personnel. Despite the standardization of ground handling practices, certification practices in the field tend to remain a relatively static procedure linked to training, testing, and re-certification. Such a framework lacks visibility into performance dynamics in between certification events, as well as any systematic evaluation of training outcomes in terms of operational practice.

This paper presents a human-centric digital twin approach to dynamic competency management in airport ground handling operations. The approach entails the integration of outputs of virtual reality training, ground handling data, telemetry of ground support equipment, apron monitoring data, and feedback into a ground handling skills passport. The suggested architecture is comprised of five interrelated layers, namely: competency definition; human-technology interaction; observable behavior; digital twin modeling; and decision support with regard to risks. This paper defines measurable indicators of competencies, suggests a pipeline for data collection and aggregation, and develops a competency and risk scoring model which would provide interpretable results. The main innovation of the paper is in the development of a conceptual and methodological framework, which may facilitate training, risk-based staffing, dynamic re-certification, and proactive safety management. An assessment protocol is designed to test whether VR-based indicators and operational data can improve predictions of deviations and competency loss compared to traditional binary certification data.

DIGITAL SHADOW-BASED RELIABILITY ASSESSMENT OF AIRCRAFT COMPONENTS WITH MODIFICATION IMPACT FACTOR

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Keywords: Digital shadow, aircraft components, reliability assessment, modification history, hazard rate; predictive maintenance

Aircraft component reliability assessment is limited by fragmented maintenance records, heterogeneous lifecycle histories, and weak integration of configuration changes with condition-related indicators. This paper proposes a digital shadow-based framework that combines an operational degradation index with a signed modification impact factor in a hazard-rate adjustment model. The interaction between degradation and modification history is treated as an optional engineering extension rather than as an empirically established relationship, and its influence is examined through sensitivity analysis. The framework is demonstrated using fully anonymized operational and maintenance records from selected component families that provide complementary evidence on configuration history, accumulated utilization, repeat removals, and transitory troubleshooting. The lifecycle-cost model is also expanded to include inspection, preventive and corrective maintenance, unscheduled removal, operational disruption, spare logistics, and non-confirmed interventions. The results show how modification history can improve lifecycle-sensitive reliability interpretation while making clear that the interaction coefficient and economic effects require further calibration with larger exposure-based datasets.



Digital Economy, Finance & Corporate Transformation

A REGIONAL APPROACH FOR AI-ASSISTED IT AUDIT ADOPTION IN THE BALTIC SEA REGION

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Keywords: Artificial intelligence, IT audit, Baltic Sea region, regional strategy, business innovation 2030, Weibull analysis, stakeholder alignment

This study develops a regional approach to AI-assisted IT audit adoption in the Baltic Sea Region. The research goal is to determine how regional fragmentation affects adoption, how stronger cooperation could change the expected diffusion path, and which capabilities are needed to support joint action. The project materials report a stakeholder map of 87 entities, 47 practitioner interviews, and a cross-sectional survey of 114 audit and IT-audit professionals. Because the original questionnaire, response-level data, interview transcripts, and coding sheets are not retained in the archive available for this revision, the survey and interview material is used only as contextual evidence. A five-stage research process combines stakeholder mapping, descriptive analysis, adoption modelling, and strategy design guided by the Regulated Intelligence Value Chain (RIVC). The stakeholder map reports that 45% of mapped actors have little or no regular regional engagement, 32% operate mainly through bilateral or limited links, and 23% participate in active multilateral initiatives. Three planning paths are compared for 2025–2030. In the coordinated case, adoption reaches 68% in 2028 and 74% in 2030, compared with 58% in 2030 under continued fragmentation. Weibull fits reproduce the six scenario points closely ($R^2 = 0.967\text{--}0.973$; RMSE = 2.08–2.80 percentage points), although these diagnostics describe fit to planning inputs rather than predictive validity. The study contributes a practical regional framework for overcoming fragmentation and supporting coordinated adoption of AI-assisted IT auditing across the Baltic Sea Region.

INTEGRATING AI WITH SAP AUDIT FRAMEWORKS: ECONOMIC ANALYSIS OF ENHANCED INTERNAL IT AUDIT EFFECTIVENESS IN THE BALTIC SEA REGION

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Keywords: Artificial intelligence, IT audit, SAP S/4HANA, ERP, continuous auditing, economic evaluation, Baltic Sea Region, RIVC

This paper examines how AI-assisted continuous auditing can be integrated with SAP and other ERP environments and under what conditions the approach produces operational and economic value. The research goal is to assess three linked issues: changes in audit effort and anomaly screening, organizational conditions that affect practical use, and the assumptions behind the economic case. The study combines a six-month matched pilot in three anonymized Latvian transport-sector organizations, a cross-sectional practitioner survey of 114 professionals used as contextual evidence, qualitative ERP configuration material, and a scenario-based economic model. The harmonized pilot outcomes are consistent with the authors' related SAP audit study: audit effort decreased from 540 to 336 person-hours (-38%), the pilot anomaly-screening indicator increased from 62% to 85%, and the reported false-positive percentage decreased from 22% to 10%. The base-case model combines EUR 20,400 in labor-capacity benefit, EUR 5,040 in modelled risk-cost avoidance, and EUR 12,000 in recurring technology cost, producing an estimated ROI of 112%. The retained research archive does not contain the event-level denominators, full survey register, or equivalent transaction-level tests across SAP, Microsoft Dynamics, and Odoo; these evidence boundaries are therefore stated explicitly. RIVC is used to connect pressure, capability, control, evidence, value, and resilience without treating model outputs as independent empirical findings.

ARTIFICIAL INTELLIGENCE IN IT AUDIT: A NOVEL FRAMEWORK FOR ENHANCED EFFICIENCY AND EFFECTIVENESS IN THE TRANSPORT SECTOR

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Keywords: Artificial intelligence, IT audit, SAP S/4HANA, continuous auditing, anomaly detection, explainable AI, transport sector

This paper evaluates an AI-assisted IT audit framework for SAP S/4HANA transport environments. The contribution is not the development of a new AI algorithm; rather, the study demonstrates how established analytical methods can be integrated into a structured audit process that combines automated analysis with governance controls, model explanations, documented evidence, and auditor review. The five-stage architecture describes how the process operates in practice, while the Regulated Intelligence Value Chain (RIVC) provides a conceptual framework for assessing organizational capability, control quality, evidence, economic value, and long-term resilience. A six-month matched evaluation across three anonymized Latvian transport-sector organizations compared a three-month baseline period with a three-month AI-assisted period. Audit effort decreased from 540 to 336 person-hours (-38%). The anomaly-screening indicator increased from 62% to 85% (+23 percentage points), while the documented false-positive percentage decreased from 22% to 10% (-12 percentage points). Because the supporting count data are unavailable in the revision archive, the two percentage measures are treated as descriptive indicators rather than inferential performance estimates. The economic evaluation uses the recorded 204-hour reduction as a conservative labor-capacity input rather than extrapolating it across future audit cycles. At EUR 100 per hour, this corresponds to EUR 20,400 in labor-capacity benefit; together with EUR 5,040 in modelled risk-cost avoidance and EUR 12,000 in recurring technology cost, the base-case estimated ROI is 112%. These results support the feasibility of the integrated workflow but should be interpreted as preliminary evidence.

ASSESSING THE ROLE AND IMPACT OF MOBILE TECHNOLOGIES IN THE LATVIAN CORPORATE SECTOR: AN EMPLOYERS' PERSPECTIVE

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Keywords: Work organisation, mobility, management, digitalisation

Latvia is witnessing the rapid expansion of the role of mobile technologies in business, regardless of the size of the company and the sector of its operation. The authors' goal was to determine the importance of mobile technologies in the daily processes of Latvian companies and their impact on business development. Empirical data were obtained from April to July 2025 using computer-assisted telephone interviews (CATI). The study sample consisted of 410 corporate clients, ensuring statistically based data comparability with the periods of previous years (2022-2024).

The main results of the study indicate a statistically significant increase in the role of mobile technologies over the year in several critical business aspects. The highest rating was identified in the category "Acceleration of information exchange in the company", reaching an average of 8.9 points on a 10-point scale. Similarly, from the perspective of employers, the assessment of technologies as a basic element for the development of new business solutions and directions, as well as their role in stimulating the creation of new jobs, has significantly increased. Conclusions and recommendations. The study confirms that technological solutions have become a pillar of efficiency and competitiveness. To promote further growth, it is necessary to focus on process simplification, automation and the introduction of innovative services (text recognition, analytics), paying special attention to the availability of solutions in the regions and promoting awareness in the small business segment.

SPORTS GLOBALIZATION AND COMMERCIALIZATION: TRENDS, DRIVERS, SPONSORSHIP DYNAMICS AND CONTEMPORARY PERSPECTIVES

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Keywords: SWOT, public transport, suburban train, Constantine metropolitan

The use of mass transport is an essential response to the mobility challenges of contemporary metropolises, particularly for reducing traffic congestion, limiting pollution, and improving access to urban peripheries. In the Constantine metropolitan area, characterized by high car ownership and a limited road infrastructure due to its rugged topography, the development of a local rail service appears as a strategic lever. However, a major paradox is observed: the commuter train, although operational for years, attracts only a very marginal ridership compared to the actual commuting needs of the population. This observation raises a central question: why is this underutilized infrastructure failing to integrate into the local mobility system, and how could it be effectively reintegrated? This article aims to propose a methodological framework for examining the feasibility of such reintegration. To do this, the authors use the SWOT (strengths, weaknesses, opportunities, threats) method, applied to the Constantine suburban rail network. The article outlines the mobility context of the urban area, describes the current state of rail services, and then presents the SWOT analysis applied to the case.

INFORMAL TRADE IN THE DIGITAL ECONOMY: PATHWAYS AND BARRIERS IN WEST AFRICA

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Keywords: Digital transformation, informal economy, e-commerce, West Africa

The relevance of this research lies in the growing tension between digital transformation and persistent socio-economic inequalities in Sub-Saharan Africa. In West Africa, the informal sector accounts for over 80 percent of employment, and digital technologies are increasingly shaping how informal traders

conduct business. However, despite the growth of mobile money systems and social commerce networks, participation in the digital economy remains deeply uneven. Drawing on the platform economy framework, financial inclusion theory, and the capability approach, this paper examines the opportunities and barriers of digital integration for informal traders in West Africa, with Ghana, Nigeria, and Cameroon as case study countries. The study employs a systematic secondary data analysis, drawing on documented sources including the GSMA State of the Industry Reports on Mobile Money (2024, 2025), the World Bank Global Findex Data-base (2021), NIBSS (2024), and regional payment system analyses, to address two supporting objectives: mapping structural and individual-level factors shaping digital platform adoption, and assessing the socioeconomic impacts of digital participation with particular attention to gender differentiation and cross-border regulatory dynamics. Findings reveal marked country-level variation in mobile money ecosystem maturity, the dominance of social commerce as the preferred digital channel among informal traders, and critical payment system fragmentation along the Nigeria-Cameroon cross-border corridor. The research contributes a comparative theoretical framework, and a documented secondary evidence base to debates on digital inclusion, platform governance, and informal trade, with direct implications for digital trade implementation and future primary research design.

FACTORS INFLUENCING THE DEVELOPMENT OF PROGRAMMATIC ADVERTISING AND THEIR IMPACT ON INFORMATIONAL ARCHITECTURE ALIGNMENT IN LATVIA

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Keywords: Programmatic advertising, artificial intelligence, informational architecture, consumer decision-making, barriers, Latvia

Programmatic advertising is considered to be data- and technology-based set of tools, whereas its practical efficiency doesn't represent the full potential of programmatic advertising. The aim of this study is to identify factors limiting growth of programmatic advertising in Latvia, as well as to indicate their impact on informational architecture alignment, considering logics behind consumer needs and decision-making process.

The study is based on a mixed-methodology research, combining both expert interviews and questionnaire of Latvian enterprises.

The main conclusion of the study suggests that the development of programmatic advertising is held back mostly by lack of competence, sophisticated legislation, market fragmentation, limited usage of behavioral data and its misinterpretation, as well as insufficient strategic integration. Companies mostly concentrate on short gains by operational benefits (targeting, cost efficiency, and management) rather than on deep comprehension of consumer needs. This creates a structural gap between meaningful identification of consumer needs and technical, but misaligned communication, which in the end leads to fragmented informational architecture.

The study significantly contributes to enlightenment that all above-mentioned factors, when perceived as a systematic mechanism, destruct and destabilize alignment of informational architecture, in the same time proving that effectiveness depends not only on technological development, but also on the balance between interpretation of available market indicators' data, strategically chosen communication measures, and deep interrogation of customer needs.

ASSESSMENT OF THE PROSPECTS FOR THE DEVELOPMENT OF INTEGRATION PROCESSES IN CENTRAL ASIAN COUNTRIES

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Keywords: Integration processes, integration factors, Central Asia

Integration remains a key tool for ensuring long-term stability and economic growth in Central Asia, where integration processes in the economy and politics continue to be actively developed, including the coordination of national models in the field of science and education. What factors influence on the development and acceleration of integration processes in the region? Assessing these factors will allow us to assess the depth and effectiveness of overall integration, and forecast future integration in the region. The object of this study is the integration processes of Central Asian countries. The subject of this research is an assessment of the factors influencing integration. The purpose of this article is to assess expert perceptions of the current state, principal factors, and future prospects of integration processes among the Central Asian countries. To conduct the scientific study, the authors formulated questions and criteria for selecting experts. The authors used the following indicators as selection criteria for selecting experts: Academic and Professional Background, Research or Practical Experience in Central Asia, Publication Record, Expertise Recognition and Professional Standing, Practical Policy-Making or Diplomatic Experience, Geographic and Institutional Diversity, Independence and Objectivity, Availability and Willingness to Participate. The presented selection criteria provide maximum reliability of the results of expert opinion. To assess the reliability of the survey, the authors employed Cronbach's alpha method. Based on these calculation results, the authors formulated recommendations.

QUIET FIRING AND QUIET QUITTING AS BIDIRECTIONAL DRIVERS OF EMPLOYER INACTION AND EMPLOYEE DISENGAGEMENT IN POST PANDEMIC RECOVERY ERA

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Keywords: Quiet quitting, human resource management, communication, corporate slavery

This research explores how quiet firing and quiet quitting are emerging as turbulent workplace phenomena. In the post-pandemic recovery era, these highlight the uncertainties and tensions between management practices and employee behavioral responses. While existing research explores employee disengagement, workplace withdrawal, burnout, and neglect as separate issues, there is limited scholarship on the bidirectional relationship between employer inaction and employee disengagement. Thus, this offers a research gap in understanding how quiet firing and quiet quitting may reinforce one another through a continuous cycle of commitment, communication, stagnation, and psychological withdrawal. The author intended to explore the extent to which quiet firing and quiet quitting function as related drivers of employer inaction and employee disengagement. The purpose was to develop an understanding of how employees and managers interpret these behaviors and how they impact workplace trust, motivation, performance, and retention. The author used a qualitative research method with a multiple-case study approach and semi-structured interviews. For case studies, three SMEs offered opportunities to observe workplace performance. 37 frontline employees, supervisors, and managers from these three SMEs volunteered to participate in the interviews. Thematic analysis was performed to identify recurring patterns and relational dynamics contributing to quiet firing and quiet quitting. The limitation of this research was the potential

subjectivity of respondents' responses, which may reduce generalizability across industries and organizational cultures. However, the novelty of this research lies in framing quiet firing and quiet quitting as bidirectional, mutually reinforcing functions rather than as separate workplace behaviors. This research benefits HRM managers, SME leaders, and others by identifying early warning signs of disengagement and strengthening employee support systems.

AI-DRIVEN MARKETING IN THE CASHLESS ECONOMY AND ITS ROLE IN DIGITAL PAYMENT ADOPTION, CONSUMER TRUST, ENGAGEMENT, AND FINANCIAL DECISION-MAKING CONFIDENCE

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Keywords: AI marketing, cashless economy, financial management, AI in Fintech, consumer behavior, digital payments

AI-driven marketing has a significant role in predictive and automated targeting, and real-time consumer communication, while linking how consumers interact with brands, financial technologies, and digital payment platforms in cashless economy. Further, while some research address adoption of cashless economy, there is limited research on how AI-driven marketing connects consumer trust, engagement rates, and financial decision-making. This gap is remarkable as today consumers rely on platform-based financial ecosystems. The authors aimed to explore the role of AI-driven marketing in the cashless economy on digital payment adoption, consumer trust, engagement, and financial decisionmaking.

The purpose was to offer empirical evidence on consumer behavior in today's progressive cashless business ecosystem. The authors used a quantitative research method. 251 valid cases were used for analysis. Furthermore, the collected data were analyzed with Structural Equation Modeling (SEM). The results suggest that AI-driven personalized marketing advances consumer engagement with digital payment platforms. This research offers practical value to marketers, banks, financial tech firms, and others by demonstrating that trustworthiness in AI-driven marketing associated with financial decision-making.

THE IMPACT OF THE 30-DAY LOWEST PRICE REGULATION ON PRICE TRANSPARENCY AND CONSUMER PERCEPTION: AN AI-ASSISTED COMPETITIVE ANALYSIS AND SURVEY-BASED STUDY

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Keywords: Price transparency, 30-day lowest price rule, EU omnibus directive, consumer perception, e-commerce, artificial intelligence, pricing strategies

The 30-day lowest price rule introduced under the EU Omnibus Directive aims to improve price transparency in e-commerce by requiring pharmacy retailers to display the lowest price applied within the

previous 30 days when advertising discounts. While this regulation is designed to protect consumers, its impact on price communication, competitive dynamics, and consumer perception in pharmacy retail remains insufficiently understood. The aim of this study is to evaluate the impact of the mandatory 30-day lowest price requirement on price transparency and consumer perception in Latvian online pharmacy retail by analyzing retailers' price communication practices and consumers' interpretation of promotional pricing. To achieve this aim, the study combines three complementary research approaches. First, it analyses how Latvian online pharmacy retailers implement the mandatory 30-day lowest price requirement and communicate promotional prices. Second, it investigates consumers' perceptions and interpretation of different price presentation formats through a structured survey. Third, the findings are interpreted in the context of the regulatory objectives of the EU Omnibus Directive and supported by secondary market data. This integrated approach enables the assessment of whether formal regulatory compliance also leads to improved consumer understanding and perceived price transparency. To strengthen the practical relevance of the research, a wider range of pharmacy retailers is included in the analysis, allowing for a more comprehensive assessment of sector-specific pricing practices within pharmacy retail. The results are expected to reveal discrepancies between regulatory intent and consumer interpretation, highlighting cases where increased formal transparency may lead to confusion or misperception. Furthermore, the study examines how different price presentation strategies influence competitive positioning among pharmacy retailers. The findings contribute to the understanding of how regulatory frameworks shape digital pricing practices and consumer behaviour in pharmacy retail. They also provide insights for improving price communication strategies and for adapting data-driven decision systems to better reflect regulatory realities in highly regulated retail sectors. This research supports the broader discussion on the role of digital transformation and AI in enhancing transparency, while addressing the challenges of aligning regulatory requirements with real-world consumer understanding in pharmacy retail e-commerce.

A CRITICAL REVIEW OF TRANSPARENCY AND EXPLAINABILITY IN AI-DRIVEN FINANCIAL DECISION- MAKING FOR CRISIS MANAGEMENT

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Keywords: Explainable AI, transparent, crisis management, AI finance, accountability and governance

Artificial intelligence is being used more in financial decision-making, including credit assessment, fraud detection, financial distress prediction, liquidity management, and insurance claims. However, relying too heavily on opaque models during a crisis can lead to serious concerns about accountability, justice, privacy, and the legitimacy of actions that affect vulnerable individuals and organisations. We aim to assess the transparency and explainability in AI-driven financial decision-making during crisis situations. A PRISMA-guided narrative review was conducted using peer-reviewed literature and relevant institutional sources addressing explainable artificial intelligence, financial decision-making, transparency, fairness, governance, accountability, and crisis management. The findings indicate existing research has advanced in the development of technical explanation methods, including feature-importance approaches, SHAP, LIME, and rule-based interpretations. However, there is no guidance for audience-specific communication, model-level explanations and institutional governance, crisis-specific explanation requirements, and methods for contesting and correcting automated choices. Technical explainability, fairness evaluation, privacy governance, human oversight, auditability, and contestability are linked to the scorecard.

DIGITAL GOVERNANCE AND THE RESILIENCE OF PUBLIC SERVICE DELIVERY IN A FRAGILE CITY: A QUALITATIVE CASE STUDY OF MOGADISHU, SOMALIA

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Keywords: Digital governance, e-government, fragile states, urban resilience, public service delivery, mobile money, hybrid governance

Fragile and conflict-affected cities increasingly use digital technology to deliver, finance, and legitimise public services, yet most research on digital governance presupposes a level of institutional capacity that such cities lack. This article analyses how digital governance shapes the resilience of public service delivery in Mogadishu, Somalia—a rapidly urbanising capital marked by acute state fragility, persistent insecurity, and one of Africa’s most dynamic mobile-money ecosystems. Using a qualitative single-case design grounded in systematic documentary analysis (2010–2026) and reflexive thematic analysis, the study integrates the design–reality gap model of e-government, resilience thinking, and theories of hybrid governance and negotiated statehood. Four themes emerge: privately owned digital infrastructure, especially mobile money, is the de facto backbone of service continuity; emerging state digital systems extend administrative reach but remain institutionally fragile; digital exclusion of displaced people, women, and low-literacy residents reproduces urban inequality; and resilience is distributed across a hybrid network of state, corporate, clan, and humanitarian actors rather than centralised in the municipality. The study argues that digital governance in fragile cities is better understood as the negotiated digitisation of hybrid political orders than as state modernisation, with implications for theory, donor programmes, and municipal policy.

AI-DRIVEN ENHANCEMENT OF THE KYC PROCESS IN COMMERCIAL BANKS

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Keywords: Artificial intelligence, KYC process, banking compliance, digital transformation, anti-money laundering (AML)

The Know Your Customer (KYC) procedure is a key element of compliance control and risk management in modern commercial banks. However, traditional KYC methods are often characterized by high cost, long processing times, and a high probability of human error. In the face of tightening regulatory requirements and the growth of digital transactions, the introduction of artificial intelligence (AI) technologies is becoming a strategic necessity for optimizing these processes.

The objective of the study is to analyze and evaluate the possibilities of using artificial intelligence to improve the KYC process in commercial banks, as well as to develop practical recommendations for the implementation of AI-based solutions.

The study uses methods of systems analysis, data classification, benchmarking of existing banking cases, and business process modeling to demonstrate the transformation of KYC procedures before and after AI implementation.

The study found that bank employees mostly support the digital solution that will be used in the KYC process. The results of the experiments showed that generative AI can reduce the time spent writing KYC scores for clients across all risk levels.

Practical recommendations can be directly applied by commercial banks for the digital transformation of compliance functions, the modernization of KYC IT architecture, and the overall enhancement of anti-money laundering (AML) efficiency.

AI IMPACT AS ENDOGENOUS TECHNOLOGICAL CHANGE IN EUROPEAN BANKS

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Keywords: AI, technology, Europe, banking

This paper analyzes the deployment of Artificial Intelligence (AI) within the European banking sector, framing such technological adoption not as an exogenous affect, but as an endogenous decision driven by institutional strategy and human capital constraints, technological readiness. Building upon Romer’s landmark endogenous technological change model, we develop a theoretical framework where profit-maximizing banks intentionally allocate resources toward AI integration, constrained by the availability and cost of specialized human skills. We adapt Romer’s triple-tier structure comprising final financial services, intermediate AI-driven software inputs, and the underlying stock of human capital to examine how the existing skill pool within European financial institutions dictates the rate and success of AI adoption. Utilizing a newly compiled panel dataset of European commercial banks from 2020 to 2025, this empirical analysis reveals that the complementarity between high-skilled labor and digital infrastructure acts as the primary engine for endogenous automation. We find that banks investing heavily in upskilling experience a compounding effect on productivity, whereas skill shortages significantly stymie technological diffusion. Ultimately, the paper demonstrates that the transformative impact of AI in banking is fundamentally bounded by endogenous talent cultivation, offering critical insights for both corporate strategy and Eurozone regulatory policy.

AI AND BIG DATA ANALYTICS FOR FINANCIAL INCLUSION AND DIGITAL FINANCIAL LITERACY IN THE SRI LANKAN BANKING SECTOR

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Keywords: Financial inclusion, financial literacy, digital transformation, artificial intelligence, big data analytics, Sri Lankan banking, FinTech

Despite the increasing trend towards digitalization, structural issues in the banking industry in Sri Lanka continue to hinder financial inclusion and financial literacy, including poor digital literacy among clients and employees, inadequate cybersecurity literacy, and gaps in the education pipeline. Such barriers deprive an entire large segment of the population of any meaningful presence in official financial systems, undermine the performance of business, and curtail the competitiveness of the industry in the long term. This research will be dedicated to the questions of digital transformation of the commercial banking sector in Sri Lanka, and, more precisely, the role of Artificial Intelligence (AI) and Big Data analytics as an enabling technology to create financial inclusion and financial literacy.

The aim is to examine the potential role of AI and Big Data analytics in enhancing digital financial literacy and financial inclusion in the Sri Lankan banking sector.

Hypotheses: H1: AI and Big Data-enabled banking capabilities have a significant positive relationship with digital financial literacy in the Sri Lankan banking sector. H2: Digital financial literacy has a significant positive relationship with financial inclusion in the Sri Lankan banking sector. H3: Cybersecurity concerns have a significant negative relationship with digital banking adoption. H4: Trust in digital banking services has a significant positive relationship with digital banking adoption.

It is also hypothesized that the coordinated investment into digital capabilities construction - in education reform, institutional training and national infrastructure - will produce quantifiably higher long-run outcomes on financial literacy, banking efficiency and GDP per capita, than there would be under a scenario where the investment is not made, or made incoherently.

Lesson Essentials and suggestions.

Short-Term: Accelerated employee digital training; digital literacy training and certification as an obligatory measure through a 15-skills scoring system through staff appraisal forms, and cybersecurity education training and pilot digital training and onboarding, paperless transactions, and AI-driven customer service.

Long-Term: Reform of education and introduction of financial literacy in schools, introduction of university courses in FinTech and Digital Banking; National Digital Banking Skills Framework; Banking Digital Academies to help maintain skills up to date; collaborative work between government, Central Bank, universities and banks; government funding of national broadband and digital identity infrastructure to make digital financial services accessible to everyone.

THE ROLE OF SMALL BUSINESSES IN THE HOUSING AND COMMUNAL SERVICES DIGITAL ECOSYSTEM FORMATION

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Keywords: Housing and communal services, ecosystem, small businesses, digitalization

Digital ecosystem of the housing and communal sector (HCS) is one of the key subsystems of a 'smart city', enabling data-driven management of buildings, utilities, resources, and public services. The authors view an ecosystem as a set of interconnected levels: digital infrastructure, data platforms, service interfaces, operational process, stakeholder networks. The main focus of this article is to understand who actually builds this ecosystem, and how do small businesses contribute to its development? The authors have sought to bring together areas such as digital transformation of the housing and communal services, urban management, and entrepreneurship, highlighting the potential for small businesses to play a central role as a key driver of digital ecosystem growth. The findings demonstrate that small business plays a central role in the digital housing and utilities ecosystem, serving as key innovators, integrators, and service providers due to their flexibility, service specialization, and knowledge of local needs and fostering collaborative development within the HCS sector.

INVESTMENT EDUCATION AND PUBLIC PARTICIPATION IN THE STOCK MARKET IN LATVIA: CHALLENGES AND DEVELOPMENT OPPORTUNITIES

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Keywords: Investment education, financial literacy, investor participation, capital market development

The research examines the role of investment education in promoting public participation in the stock market in Latvia. The topic is particularly relevant due to growing public interest in investing, the rapid development of financial technologies, and the need to improve financial literacy. During the last two years, the number of clients holding securities or investment accounts in Latvia increased by 51%, invested capital by 71%, and the number of investors aged 18–21 by 818%. These trends highlight increasing interest in the capital market and the importance of investment education for informed financial decision-making, risk awareness, and the development of a sustainable investment culture.

The aim of the study is to examine the significance of investment education in promoting public participation in the Latvian stock market and to develop conclusions and recommendations.

To achieve this aim, the study analyses scientific literature on investments, financial literacy, and capital market participation, evaluates secondary data on investment education initiatives, and examines the results of surveys conducted by the Bank of Latvia and the authors, together with expert interviews, to assess investment knowledge, attitudes, and the effectiveness of educational measures.

The research applies monographic, statistical, and quantitative methods and is based on scientific literature, statistical data, survey findings, and expert interview results.

The findings confirm that investment education improves public understanding of capital market operations, supports informed financial decision-making, and encourages participation in investment activities. However, insufficient knowledge and fear of financial losses remain the main barriers to investing.

Based on the findings, recommendations were developed for the Bank of Latvia, the Ministry of Education and Science, policymakers responsible for economic and capital market development, and commercial banks. The recommendations focus on strengthening investment education, expanding public information initiatives, improving financial literacy, and increasing public participation in Latvia's capital market.

ANTI-MONEY LAUNDERING IN LATVIA: CURRENT TRENDS, CHALLENGES AND OPPORTUNITIES FOR IMPROVEMENT

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Keywords: Anti-Money Laundering (AML), financial crime prevention, financial sector supervision, commercial banks

Money laundering (ML) is one of the most significant financial crime challenges worldwide, posing threats to financial system stability, the investment environment, and public trust in state institutions. The relevance of this issue in Latvia is demonstrated by both the requirements of international organizations and the country's experience in implementing financial sector reforms following MONEYVAL and FATF recommendations. As digital technologies continue to develop, new money laundering risks are emerging, particularly those associated with digital financial services and the use of artificial intelligence.

The aim of the article is to examine the role of the Bank of Latvia, the Financial Intelligence Unit (FIU), and commercial banks in combating money laundering in Latvia and to develop proposals for improving the national anti-money laundering (AML) system. To achieve this aim, an analysis of scientific literature, legal regulations, and statistical data was conducted. The study also assessed Latvia's approach to implementing FATF standards and MONEYVAL recommendations, analyzed the activities of the Bank of Latvia, the FIU, and commercial banks, and included a survey and interviews with industry experts.

The study found that Latvia has significantly strengthened its AML system in recent years. According to FIU data, 6,108 suspicious transaction reports were received in 2023, and EUR 91.68 million in potentially criminal proceeds were frozen. Since 2018, the total amount of frozen assets has exceeded EUR 1.5 billion.

Both qualitative and quantitative research methods were employed. The empirical part of the study included statistical data analysis and the analysis of interviews with industry experts. A graphical method was used to present and visualize the research results.

Based on the research findings, proposals were developed for the Bank of Latvia, the FIU, the State Revenue Service, the Finance Latvia Association, commercial banks, and other law enforcement institutions. The proposals focus on improving information exchange, strengthening international cooperation, expanding the use of artificial intelligence in supervisory processes, enhancing professional competencies, and increasing public awareness of money laundering risks.

AI-ENABLED CUSTOMER COMMUNICATION AND E-COMMERCE PURCHASE BEHAVIOR IN SOUTH ASIA: A STRUCTURAL EQUATION MODELING APPROACH

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Keywords: AI-enabled customer communication, digital communication, communication quality, e-commerce purchase behavior, structural equation modeling, South Asia

Artificial intelligence (AI) is increasingly used in e-commerce to provide responsive and personalized customer interactions, yet evidence on how digital communication, AI-enabled communication, communication quality, and purchasing behavior operate together in South Asia remains limited. This study examines the relationships among Digital Customer Communication (DCC), AI-Enabled Customer Communication (AIEC), Communication Quality (CQ), and E-Commerce Purchase Behavior (EPB). Survey data from 499 online consumers in Pakistan, India, Bangladesh, and Sri Lanka were analyzed using covariance-based Structural Equation Modeling (CB-SEM) in Python. The results show that DCC positively influences AIEC, CQ, and EPB; AIEC positively influences CQ and EPB; and CQ positively influences EPB. The strongest relationship was from DCC to AIEC ($\beta = 0.754$, $p < 0.001$). The findings validate an integrated framework linking digital and AI-enabled communication with communication quality and purchasing behavior. Overall, for e-commerce businesses in South Asia, the results emphasize combining AI technologies with responsive, personalized, and culturally appropriate communication to strengthen customer engagement and purchasing outcomes.

EVIDENCE-AWARE ASSESSMENT OF INFORMATION-FLOW RELIABILITY IN DIGITAL CONSTRUCTION ECOSYSTEMS

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Keywords: Structured data logistics, failure-mode taxonomy, evidence uncertainty, construction data interoperability, AI readiness, lifecycle information reuse

Digital construction ecosystems connect BIM, CDEs, schedules, cost systems, field evidence and analytical platforms, yet downstream decisions may still receive late, incompatible, untraceable or non-reusable information. This paper develops an evidence-aware method for assessing the reliability of bounded structured-information flows that support AI-assisted construction decisions. A design-science-oriented synthesis combines Failure Mode and Effects Analysis (FMEA) logic with four Structured Data Logistics (SDL) dimensions: Information Movement, Interoperability, Traceability and Information Reuse. Failure likelihood, consequence severity and evidence-support uncertainty are rated on fixed ordinal anchors and combined as a conservative screening index; the product is not interpreted as a probability or interval-scale measure, and uncertainty remains separately auditable. A hypothetical delay-and-rework example tests calculation behaviour under assumed control scenarios. The baseline reliability profile is 0.785, 0.602, 0.667 and 0.492; a combined scenario yields 0.882, 0.860, 0.856 and 0.879. These values are illustrative and do not represent measured project performance or verified control effectiveness. The method provides a diagnostic profile of information-flow weaknesses; empirical validation requires expert content validation, independent raters, interrater reliability testing, sensitivity analysis and comparison with observable project outcomes.

BEYOND LINEAR LOGIC: MODELING INTERDEPENDENT CRITERIA IN PARENTAL DECISIONS TO HIRE OFFSPRING USING THE ANALYTIC NETWORK PROCESS

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Keywords: Parental decision-making, analytic network process, social cognitive theory, next-generation employment

Parental decisions regarding the employment of their children within family firms are governed by a complex configuration of cognitive, motivational, and contextual forces that interact in non-linear ways (García-Álvarez & López-Sintas, 2001). Despite the recognized importance of parental beliefs, empirical research often fails to capture the systemic interdependencies inherent in these decisions. This paper addresses this gap by applying the Analytic Network Process (ANP) to investigate the complex decision-making process through which parents select and hire their children as employees and potential successors in their business. Grounded in Social Cognitive Theory, we conceptualize parental decision-making as a network of interconnected judgments across cognitive clusters, dual environmental contexts, and role configurations.

To manage the cognitive load of high-dimensional criteria, we utilize a hybrid rating-based ANP approach, deriving global priorities from a supermatrix that accounts for feedback loops between Personal Node, Dual-contextual pressures and Behaviour outcomes-possible roles configuration. Our findings reveal

a distinct hierarchy of influence: parental self-efficacy and outcome expectations emerge as the primary drivers, outweighing external labor market conditions and non-family stakeholder concerns. This suggests that the decision to employ children is governed more by the parent's perceived capability to mentor than by external economic rationality. By mapping the cognitive architecture of these judgments, this study demonstrates the utility of ANP in capturing the “messy” reality of family business decisions and offers a structured framework for future research on human capital in family enterprises.

HUMAN RESOURCE RISKS WITHIN THE FINANCIAL INDUSTRY

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Keywords: HR risk, financial sector, risk interdependencies, PLS-SEM, risk management

Despite the growing recognition of human resource as a critical source of systemic risk in the financial sector, academic research and regulatory frame-works still do not pay proper attention to HR Risk as a distinct and measurable domain. This study examines the interdependencies between HR Risk and key risk categories, including Operational, Legal, AML, ESG, Strategic and Governance risks. The principal research and models construction are implemented with employment of Partial Least Squares Structural Equation Modeling (PLS-SEM). The developed PLS-SEM models first of all demonstrate the lack of understanding the nature and interrelations of HR risk in the financial entity risk framework (Model 1) and allow covering the existing gap in the approach towards HR Risks (Model 2). The study results comprise the development of 2 statistical models. Model 1, based on a set of threats traditionally used by financial institutions for determining HR risks, explains only 12% of the variance. Model 2, incorporating HR-specific factors determined by the authors, presents significantly higher results: R^2 is 85.2%, all six used risk constructs have strong impact on HR Risk ($p < 0.001$). The results demonstrate that HR Risk is deeply interconnected with Governance, Operational and Governance Risks, ESG, AML.



Logistics & Supply Chains

OPERATIONAL CHALLENGES IN THE APPLICATION OF UAV'S TO DIRECT LOGISTICAL SUPPORT OPERATIONS

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Keywords: Unmanned aerial vehicles, military logistics, direct logistical support, Lithuanian Armed Forces, defence technologies

Contemporary armed conflicts underscore the importance of military logistics and the necessity of applying new technologies to ensure continuous fulfilment of armed forces' needs. The experience of Ukraine has shown that traditional supply assets, such as transport columns and convoys, are identified and destroyed too easily. Unmanned aerial vehicles (UAVs) are increasingly employed to address critical direct logistical support tasks. UAVs can address critically important logistical issues: delivery of ammunition, the replenishment of food supplies, the provision of first-aid equipment, and other tasks. The application of UAVs in logistics at the NATO level is regarded as one of the most important directions of military innovation. Nevertheless, although the use of UAVs in military conflicts has demonstrated their applicability in supply operations, there is a lack of systematic analysis of how these technologies can be integrated into the logistics support system of the Lithuanian Armed Forces. To eliminate this gap of knowledge the article first examines the theoretical aspects of the application of UAVs in ensuring direct logistical support and subsequently compares the conclusions of this analysis with the results of an empirical study aimed at identifying the problems associated with the use of UAVs in ensuring direct logistical support in the case of the Lithuanian Armed Forces.

CONSIDERATION OF TRANSIT INVENTORY IN NON-CIVILIAN APPLICATIONS OF ECONOMIC ORDER QUANTITY MODEL

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Keywords: Supply chain disruption, resilience, EOQ, humanitarian logistics, military logistics

Economic Order Quantity (EOQ) is a well-known classic model in inventory control applicable in deterministic and, under certain situations, stochastic demand scenarios. Despite its theoretical value, the model hasn't been widely used in business due to its restrictive assumptions and difficulty of estimating parameters. Even less known are EOQ applications outside of for-profit organizations, but these alternative areas, such as military and humanitarian logistics, can be particularly relevant. This study aims at investigating applicability of the EOQ model extensions with transit inventory during or before involving conflicts and natural and other disasters. Analytical modeling and simulation demonstrate differing result of the model for optimal order to minimize logistics costs with inventory in transit, even when this is not the main objective of an organization. This investigation is timely given increasing global uncertainty in the global supply chains and geopolitics after the pandemic outbreak of 2020.

OPPORTUNITIES FOR DEVELOPMENT OF TRANSPORT AND LOGISTICS IN CENTRAL ASIA AFTER SUPPLY CHAIN DISRUPTIONS IN 2020-2025

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Keywords: Logistics, transport, circuitry factor, LPI, Central Asia

After the global pandemic outbreak in 2020, the world entered the prolonged period of increasing uncertainty. The ensuing trade wars exacerbate global volatility brought by a series of the regional conflicts during the 2020s. The current situation as of 2026 due to the recent disruptions affected the logistics sector particularly strongly with the associated risks for Central Asia. How are transport and logistics sectors developed in Central Asia and can the region benefit from opportunities arising from the global supply chain reconfiguration in the 2020s? To answer the question, this study starts from review of related research in global value chains and analysis of data on logistics performance from publicly accessible sources. It then proceeds to explore connectivity using estimations of circuitry factors for major economic and population centers of the region. Central Asian countries recently remained in the medium to lower positions in the global ranking of logistics development. Transport network in many parts of the region can be considered underdeveloped. Policymakers in the regions faced unique challenges in realization of the potential of alternative routes and regional partnerships. Results help wider audience better understand the importance of global value chains and other less studied factors in the development in transport sector of the regions with their increasing role in the sustainable development.

IMPROVING THE INFORMATION SYSTEM OF A FORWARDING COMPANY'S TRANSPORTATION PROCESSES: A LITHUANIAN CASE STUDY

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Keywords: Freight forwarder, information systems, automation, transportation process, Delphi method, expert evaluation

With the growth of freight flows, increasing complexity of supply chains, and strengthening international trade relations, freight forwarding companies are required to continuously improve their operational processes and implement advanced digital solutions. The purpose of this study is to investigate the factors of information systems used in transport processes and propose the stages of an implementation plan for improving information systems of Lithuanian freight forwarding companies. In freight forwarding activities, information systems are the most important tool for efficiently managing order intake, transportation planning, documentation handling, cargo tracking, communication with clients, and financial settlements. The Delphi method, involving several stages of expert evaluation, was applied in this research. The study revealed that due to the largest amount of information processed in the Lithuanian freight forwarding sector, the most important need for improvement is the information system capability in the organization of transport processes. The study revealed that the Lithuanian freight forwarding sector still frequently faces a high volume of manual work and an increased risk of errors, which reduces operational efficiency and company competitiveness.

SMART LOGISTICS IN PRACTICE: EVALUATING THE ROLE OF IOT IN LOGISTICS SERVICE PROVIDERS

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Keywords: Internet of Things (IoT), logistics service providers (lsps), smart logistics, supply chain efficiency

In the rapidly evolving digital logistics landscape, the Internet of Things (IoT) is transforming how logistics companies operate and compete. This paper examines the practical implementation of IoT solutions within logistics service providers, with a focus on the Lithuanian market. The research combines theoretical analysis of IoT architecture and functionality with empirical data collected through a structured survey of logistics firms. The study identifies key areas of IoT application in transport, warehousing, tracking, and information management processes, highlighting both the benefits and challenges of integration.

Results indicate that IoT adoption is associated with reported improvements in information flow, operational visibility, and customer satisfaction. The findings show that positive short-term returns from IoT adoption do not necessarily translate into long-term economic feasibility, as investment viability remains sensitive to the extent to which expected operational benefits are realised. By combining survey evidence with ROI, BCR, and sensitivity analysis, the study provides an integrated operational-economic perspective on IoT adoption in logistics service providers and offers a practical framework for assessing digital technology investments.

RETHINKING SPILLOVERS: NONLINEAR VOLATILITY CONNECTEDNESS IN EUROPEAN FINANCIAL INSTITUTIONS – A SHAPLEY ATTRIBUTION APPROACH

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Keywords: Volatility spillovers, financial connectedness, SHAP, XGBoost, European banking, systemic risk, nonlinear transmission, rolling window analysis

This paper reconstructs the Diebold-Yilmaz connectedness framework around two different components: XGBoost in place of the linear VAR, and SHAP attribution in place of variance decomposition. The Diebold-Yilmaz framework, while widely adopted, assumes linear and time-invariant market interactions, an assumption difficult to reconcile with the nonlinear dynamics of financial volatility, particularly during periods of stress. For each of the 29 major European financial institutions in the sample, a separate XGBoost model is trained to predict weekly realized volatility using the lagged volatilities of all institutions as inputs. SHAP attribution is then applied to decompose each prediction into institution-level contributions, aggregated into a spillover matrix that mirrors the structure of the Diebold-Yilmaz connectedness table while relaxing its linearity assumption. To our knowledge, this is the first application of SHAP-based attribution to the construction of a financial connectedness index. The static analysis yields a Total SHAP Spillover Index of 88.34%, for the period of 2007-2024, substantially exceeding linear benchmarks for comparable samples, with a small cluster of institutions, emerging as dominant volatility transmitters. A dynamic extension introduces a Net Dynamic SHAP Spillover Index estimated across rolling windows of 52, 100, and 200 weeks, capturing time-varying connectedness and responding clearly to major stress episodes including the 2011-2012 European sovereign debt crisis and the market turmoil of 2020.

BEYOND VARIANCE: AN INFORMATION-THEORETIC EXTENSION OF THE DIEBOLD-YILMAZ CONNECTEDNESS FRAMEWORK WITH EVIDENCE FROM EUROPEAN BANKING

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Keywords: Transfer entropy, variance decomposition, information theory, financial connectedness, Diebold-Yilmaz connectedness

The Diebold-Yilmaz connectedness framework has become a cornerstone of empirical systemic risk analysis. However, its reliance on variance decomposition confines it to the second moment of the return distribution. This limitation may become consequential during periods of market stress when financial institutions interact through channels that trigger nonlinear shifts in the distribution of the systemic risk. We propose a composite connectedness index that augments the variational decomposition approach with a model-free transfer entropy metric grounded in an information-theoretic perspective. We demonstrate our results on a 17-year dataset of 29 European banking institutions, yielding a directional information flow matrix that, when combined with the standard Diebold-Yilmaz connectedness framework, captures dependencies that variance decomposition leaves undetected by construction. Our key finding is the systematic divergence between variance-based and information-based institution rankings: several institutions that appear peripheral under conventional spillover measurement emerge as major information transmitters once nonlinear dependencies are accounted for, while some institutions prominent in the Diebold-Yilmaz ranking recede in information-theoretic importance. We formalize this divergence through a composite systemic importance index that nests both measures under a parametric formulation, offering regulators and researchers a flexible diagnostic tool for identifying and understanding the systemic footprint of institutions within multiple theoretical frameworks.

INTEGRATING IOT INTO SUSTAINABLE LOGISTICS AND SUPPLY CHAIN MANAGEMENT

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Keywords: Internet of Things (IoT), sustainable supply chain management, smart logistics

The Internet of Things (IoT) is a game-changer in sustainable logistics, enabling real-time data collection and decision-making to enhance supply chain transparency, efficiency, resilience, and environmental performance. This study collates current information on IoT adoption in sustainable logistics, including the key application areas, enabling technologies, and sustainability impacts driving the field. The review shows that IoT is being adopted as a core component of a digital ecosystem that integrates technologies such as blockchain, artificial intelligence, big data analytics, digital twins, and cloud computing to enhance traceability, transportation optimization, warehouse management, predictive decision-making, and supply chain resilience. An important contribution of this study is its use of an integrated thematic synthesis approach, which advances existing knowledge by connecting IoT architectures to aspects of sustainability (environmental, operational, economic, governance) rather than considering technologies in isolation. The results also show that the strategic potential of the IoT goes beyond operational automation to the creation of data-driven, adaptive, and resilient logistics systems, designed for Industry 4.0 and sustainable supply chains. However, its full scale-up has been hampered by interoperability problems, the risk of security breaches, the massive deployment costs, data governance concerns, and the readiness of the various organizations. The review is limited in that it relies only on published peer-reviewed evidence and on the lack of consistency in the industry context, which may limit the generalizability of the findings. Longitudinal and cross-sector empirical studies are needed in the future to assess the sustainability effects and scalability of IoT-based logistics ecosystems.

IMPLEMENTATION OF A SATELLITE-BASED ALTERNATIVE TO UAV MONITORING IN AZERBAIJAN'S AGRICULTURAL SECTOR TO IMPROVE EFFICIENCY

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Keywords: Satellite-based monitoring, UAV alternative, agriculture, monitoring, Azerbaijan

The modernisation of agricultural monitoring systems represents a critical component of digital transformation in developing economies, where the need for scalable, cost-effective management solutions is particularly acute. Traditional monitoring approaches, field inspections and manual measurements, remain limited in spatial coverage and operational efficiency, while UAV technologies, despite high precision, face significant regulatory, financial, and infrastructural barriers to large-scale deployment. The subject of this research is the efficiency of satellite-derived vegetation indices as a cost-effective alternative to UAV-based agricultural productivity management; the object is wheat yield across the districts of Azerbaijan; the goal is to assess this alternative's capacity to improve agricultural monitoring efficiency and yield prediction in Azerbaijan. Based on panel data covering 10 districts over 2000-2024, the author integrates MODIS-derived NDVI indicators across early, mid, and late growing-season stages with ERA5 climate variables within a two-way fixed effects regression framework, without field surveys or UAV deployment. The full model achieves $R^2 = 0.459$ (RMSE = 0.417 ton/ha), with mid-season NDVI, early-season temperature, and total precipitation as the most robust predictors under serial-correlation- and dependence-robust standard errors; a nested out-of-sample validation across four holdout lengths (final 1-

4 years) yields MAPE values ranging from 14.0% to 22.6%, confirming that explanatory fit and forecasting accuracy differ and should be reported separately. The approach offers a replicable methodology for food security governance in data-scarce environments.

REVERSE LOGISTICS FOR REUSABLE PACKAGING: BUSINESS MODELS FROM BALTIC SEA REGION

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Keywords: Reverse logistics, reusable packaging, sustainable business models, green transition, baltic sea region

Against other issue, green transition is defending its position on the top of the political agenda, especially when greening is related with resource savings and cost advantages. In this context, reusable packaging is increasingly regarded as a promising alternative to single-use solutions in green transition. However, the implementation of business models for reusable packaging remains challenging, since the environmental and economic benefits of reuse depend largely on the efficient organization of return flows. This study examines the role of reverse logistics in reusable packaging systems and aims to identify the key factors that enable or hinder their effective functioning. The study argues that the success of reusable packaging systems depends not only on the design of the packaging itself, but also on the feasibility, reliability, and cost-efficiency of the reverse logistics process. By addressing this issue, the paper contributes to current discussions on the role of logistics in circular economy and offers practical insights into the conditions of a successful implementation of sustainable business models of reusable packaging. The authors take part in the EU-project “BePacMan” and uses empirical data that were collected in 2025 within the frame of the project. The methodology is based on case studies that are complemented by expert interviews of companies operating with reusable packaging solutions in the southern part of the Baltic Sea Region. The findings highlight sustainable return procedures, customer involvement, and cooperation of logistics partners.

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